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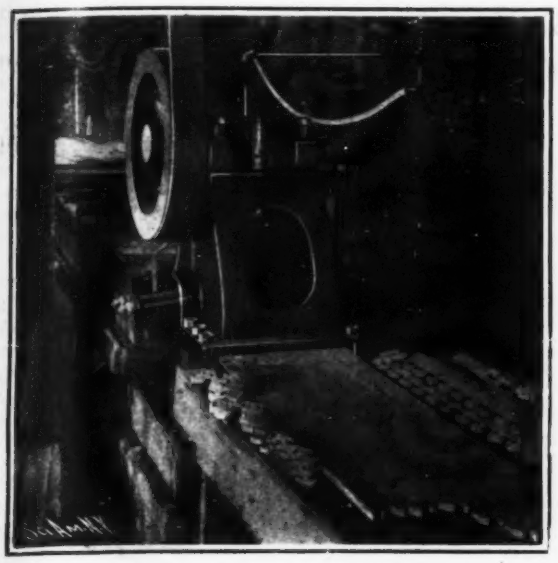
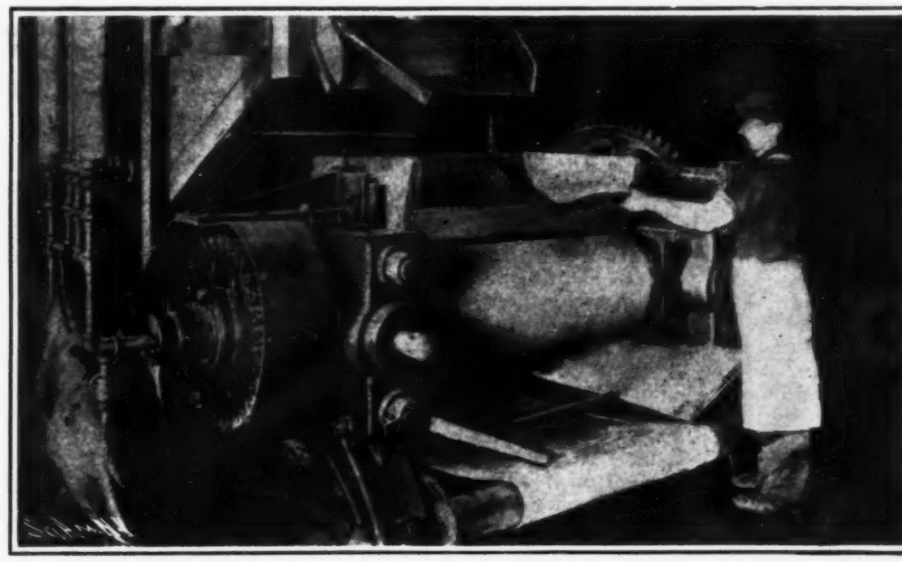


Machine for Cutting Out Rubber Tiles.



Machine in Which Scrap Rubber is Ground and Sifted.

Running a Load of "Rubber Shoddy" Into the Devulcanizing Cylinder Where, Under Action of Steam Heat, the Sulphur is Extracted.

THE RUBBER INDUSTRY OF TO-DAY—[See page 212.]

The Great Star Map.—V*

Star Positions.—Continued

By H. H. Turner, DSc., D. C. L., F. R. S., Savilian Prof. of Astronomy in the University of Oxford

Continued from Supplement No. 1864, page 203

Let us now consider what is to be the outcome of this immense piece of work. What are we likely to learn from these millions of measurements? As already stated, the interest will come when it is repeated—in the study of the movements of the stars; which are so minute that, as a rule, at least a century is required to discern them even by our improved modern methods. The movements are not really slow; we may take the velocity of our earth in its annual journey round the sun—about 20 miles a second—as a fair sample of the velocities of the stars. But our great journey from side to side of the sun (nearly 200,000,000 miles across) would seem a minute movement to the nearest star, and to the great majority would be imperceptible. This is however not the only movement of the earth; the sun himself is moving and we partake of that motion also. It is not a circling or oscillatory motion, but is in the same direction year after year, so far as we can at present ascertain, the distance traversed each year being about 400,000,000 miles. One year's journey is therefore scarcely more perceptible from the distant stars than the circling movement of the earth; but as year follows year the successive steps add together and the cumulative effect becomes ultimately perceptible even to very distant stars. Now all the stars are moving in this way—persistently in the same direction—year after year. Hence, though the movement in one year may be imperceptible, by waiting ten years or twenty or a century we ultimately perceive the movements of many of them. The more distant require even longer —how much longer we cannot yet say—this is one of the questions on which we hope to get some light by the work on the Great Star Map and its successors. Our knowledge will grow: We shall find that after ten years a certain percentage of the stars have moved; after twenty, new movements previously undetected or uncertain, will be added; after thirty, more still, and so on; and by watching the run of the sequence we may even be able to predict what will happen in longer periods not yet reached, though this extrapolation has its risks.

We cannot, of course, afford to repeat the whole map every ten years; we must be satisfied with samples made as representative as possible. We have already obtained some samples at Oxford and the following results will serve to illustrate our expectation. Plates have been repeated after intervals varying from ten years to seventeen and the measures compared. If the measures of any star in either coordinate differed by more than 1.2 seconds (the angle subtended by an inch at a distance of 2½ miles) they were carefully repeated. In a number of cases the discordance was found to be due to some mistake or a careless measure. (It must be remembered that many thousands of measures were made in all, and that occasional mistakes are inevitable.) But in the majority the difference was confirmed as due to a real movement of the star. Such movements were nevertheless very rare—on the average less than 2 per cent of all the stars examined.

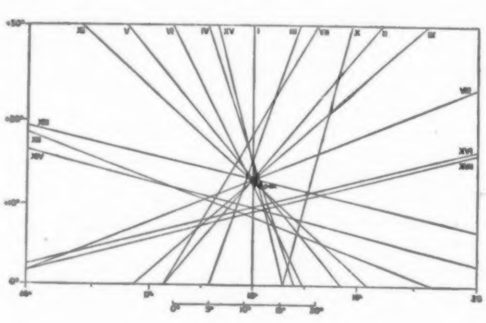
The percentage was higher for the longer intervals somewhat as follows:

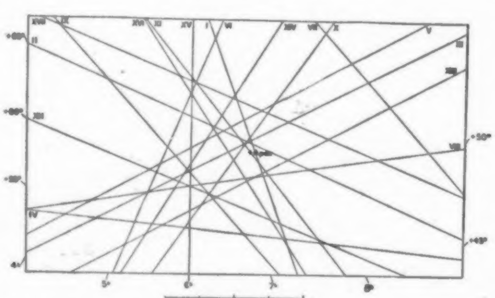
After 10 years, 1 per cent had moved appreciably.
After 12 years, 1½ per cent had moved appreciably.
After 14 years, 2 per cent had moved appreciably.
After 16 years, 2½ per cent had moved appreciably.

But this method of statement is defective by reason of a most significant fact brought to light by the results themselves.

Of the plates examined for these movements some were of regions in the Milky Way thickly populated with stars—say 500 or 600 on a plate; others were of regions remote from the Milky Way and contained only 50 or 60. [These numbers are smaller than they should be; that is why the plates were repeated and the comparison rendered possible.] Now we might naturally expect to find more moving stars among the 500 than among the 50, but we do not; there are just as many per plate (that is to say on a given sky-area) in any part of the sky, whether it be densely or sparsely covered with stars. It is as though a fall of snow had collected into huge irregular drifts and then a shower of rain fell. The number of raindrops falling on a given area would have nothing to do with the quantity of snow upon it already, and we should only make confusion by expressing the rain as a percentage of the snow on the area. Similarly we must give up the idea of finding so many sensible movements per cent of the stars on a given area and think of the number per unit area, irrespective of the population by other stars. The moving stars are in fact distinct from the others in some way, and it is pretty clear that the distinction consists in their being considerably nearer to us. If this be the correct interpretation, we infer that the stars near us are scattered more or less uniformly and do not show the structure which is so striking a feature of those more distant. This is a fact of fundamental importance and suggests from a new point of view the idea of a solar cluster—a group of stars of which our sun is one standing somewhat apart from its distant surroundings—which was suggested by the counts of stars of different magnitudes as described in the last article.

And its importance is enhanced in consequence of a great discovery made within the last few years, that there are two great streams of stars meeting one another. It was assumed until about 1904 that the movements of the stars were at random in all directions; in that year Prof. Kapteyn of Groningen showed that this could not be the case,[1] but that there must be at least two main streams of stars passing one through the other. This suggestion has been confirmed by elaborate investigations of Eddington, Dyson and others: and in particular Prof. Dyson (now astronomer royal) showed that this bifurcation was specially characteristic of the largest proper motions; this is to say, the stars nearest to our sun are moving in this way in any case, whatever may be the real facts about the more distant stars of which our knowledge is still uncertain and incomplete. Is there any reason for thinking that the bifurcation characterizes *only* the nearest stars and ceases beyond? One such reason has already been indicated; the nearest stars are apparently distinct from those more remote which cluster toward the Milky Way. Hence the bifurcation must be proved independently for these remoter stars, since there is apparently a breach of continuity.





Figs. 1 and 2.—Mr. Eddington's Diagrams of the Convergence of Movements from Seventeen Pairs of Regions Covering the Whole Sky.

Note.—Each picture represents a portion of the celestial sphere corresponding nearly to that occupied by Europe on the terrestrial sphere.

But another reason has been suggested also. In a most interesting lecture on the Milky Way, delivered to the British Association at its South African meeting,[2] Mr. A. R. Hinks of Cambridge developed the idea that the Milky Way was made up of a number of independent star-clouds or clusters. If these are in relative motion, as they presumably are, there will be occasions on which one cloud meets another. The stars in each being widely scattered, one will pass through the other freely, without much risk of collision between any of the members. This supposition would explain all the main facts as we know them at present; but we cannot say how far it will fit in with facts to be discovered in the future, when we have compared plates taken at greater intervals, and begin to learn something of the movements of the more distant stars.

By the kindness of Mr. Eddington (chief assistant at the Royal Observatory, Greenwich) I am enabled to reproduce two diagrams (Figs. 1 and 2), which show the very latest piece of evidence in favor of the existence of these two star-drifts. It should first be precised that since a series of parallel lines, such as the parallel edges of a box, appear to us to converge to a point (the "vanishing-point" of perspective), so a cluster of stars moving in parallel paths, like a flock of migrating birds, would seem to us to have movements converging to a definite point in the heavens. A beautiful instance of such convergence among some stars in the constellation Taurus was detected a couple of years ago by Prof. Boss of Albany, N. Y. He had suspected its existence for nearly twenty years, but the knowledge of the stellar motions was too inaccurate to convert his suspicion into certainty. This has only come with the completion of a vast research on the movements of the stars which he has conducted with infinite patience: removing one source of error after another by a laborious series of approximations until at last he was able to produce a catalogue of movements freed, as far as possible, from all discernible systematic errors. Incidentally he got values for the motions of the Taurus cluster sufficiently accurate to make it clear that they were apparently converging to a point. With this clue and the help of spectroscopic observations he was able to determine the distance of the cluster to be 120 light-years away from us (that is, light from the cluster takes 120 years to reach us; the distance in miles, if that be preferred, is 800 million million); and it is receding in an oblique direction. It passed us closest about 8,000 centuries ago, at about half its present distance; and he gathered further particulars of its history and shape, which we can scarcely stop to notice here. One further point, however, is of importance. The individual stars seem to keep their places in the procession without internal rearrangement—they move in almost strictly parallel lines and at the same pace.

Now the streams of stars to which Kapteyn called attention are of a different kind; the internal movements are considerable; it is only the average movement which is steadily in one direction. But when we take such average movements in different parts of the sky they tend to converge to a point like the actual motions of the individual stars of the Taurus cluster. It is this convergence of average movements which Mr. Eddington has represented so beautifully in his diagrams. He divided the whole sky into thirty-four areas, and found (from the great catalogue of movements just published by Prof. Boss) the average movements in each area. It would take too long to explain how he identified the average movement for each of the two drifts: it must suffice that the process was ingenious and effective.[3] He was able to draw the two lines for each of the thirty-four regions, or rather for each of seventeen pairs which he preferred to use. The test of the validity of the hypothesis is that these lines should converge to two points in the sky representing the goals toward which the two clouds of stars are drifting. The reader can judge for himself. In one case the convergence is very striking. It is not, of course, perfect: we could scarcely expect perfection when dealing with averages of imperfect observations, but the approximation is clearly a very close one. In the other case the convergence is less marked, but the reality is brought home to us by an analogy. "If from seventeen points," writes Mr. Eddington, "distributed uniformly all over the earth, tracks (great circles) were drawn, every one of which passed across the Sahara, they might fairly be considered to show strong evidence of con-

* Reprinted from *Science Progress*.

[1] A few months later Mr. H. C. Plummer independently pointed out the same fact. (*Mon. Not. R.A.S.* vol. lxv, p. 568.)

[2] See an abstract in *Proc. Camb. Phil. Soc.* vol. xiii, Pt. IV.

[3] Those who care to read more will find Mr. Eddington's paper in the November number of the Monthly Notices of the Royal Astronomical Society. It gives references to previous work.

vergence: The distribution of the 'drift II.' directions is quite analogous."

We may note yet one more point in this very interesting paper. Eddington found that there was a whole class of stars which it was better for him to exclude. They seem to have a common motion of their own, like that of the Taurus cluster. Moreover, their spectra are all alike (of the Orion type), which is further evidence of relationship; and finally they present two indications of great distance—first that their apparent movements are very small, and next that the stars themselves cluster towards the Milky Way. (We have seen that the stars presumably near to us have large proper motions and are distributed indifferently.) The inference that the distant stars forming the Milky Way do not share in Kapteyn's two drifts seems to be plain. Recurring to Hinks's idea of star clouds, it seems probable that these "Orion" stars belong to a distant cloud, distinct from the two which have met and mingled in our neighborhood. But before we can accept these rough suggestions we must do much more work in the examination of stellar movements, such as it is the object of the promoters of the Great Star Map to initiate.

One feature of such work on the stars which impresses itself deeply on the consciousness of those who undertake it is worthy of more than passing notice, though it may not be easy to communicate the impression to others. In dealing with the comparison of the places of thousands of stars at two different epochs, a feeling of awe is evoked on finding so few cases of change. As one turns over page after page of records and sees at a glance that the differences are too small to be significant, the first feeling of mere satisfaction at the accuracy of the measurement gradually yields to this growing sense of the profundity of the depths of space which makes this awful stillness. It might not be suspected that pages of figures could serve to develop so sentimental an impression. The layman would be prepared to learn that the observer of distant stars in a huge telescope might feel emotion, but figures, especially in a cataract of thousands, seem far too prosaic. Nevertheless the interpretation of the figures becomes with practice a very rapid mental process, so that one sees behind them the realities they indicate.

A long piece of work of this kind is indeed effective in condensing a number of mental processes. Another illustration of a very different kind may be given. It has been already explained that to guard against mistakes each plate is measured twice over in reversed positions. The two measures of any star are represented by quite different figures, connected by the rule that their sum must represent the whole width of the plate, 26.000. Thus, if the first measure be 8.352, the second (in the reversed position) should be 17.648; since the sum of these two numbers makes 26.000. Now it will be seen that one of these numbers can be derived from the other by the following processes: Subtract 8 from 25 and we get 17; subtract 3 and 5 each from 9 and we get 6 and 4; subtract 2 from 10 and we get 8. This is a straightforward but not very simple mental operation, which most of us would perform for the first time with some wariness. It fell to the lot of one of the computers at Oxford to perform it many thousands of times in reading proof-sheets. He presently became so adept that it was easier for him to read the derived figures than the direct ones! If set to read actual figures before him in the usual way, he would stumble; but allow him to transpose them as above and he proceeded with confidence and accuracy. We know that the picture of external objects which falls on our retinas is inverted, and that nevertheless there is no consciousness of inversion in our perception of them; and this result has been ascribed (though not without misconception) to long habit. It was, however, quite new to me to find that the mental process described above could be rendered automatic by the practice of a few months.

(To be continued.)

Length of Wood Fibers

The Microscopic Structure of Ligneous Tissue

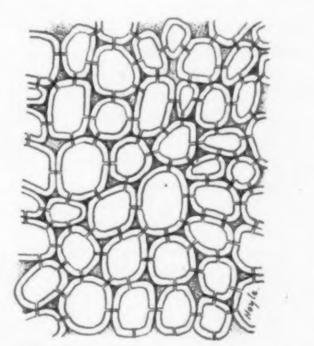
WOOD fibers require special preparation for microscopic examination. The elements composing wood are isolated by means of the Schultze's maceration mixture, which consists of dilute nitric acid and potassium chlorate. Small chips of the wood are placed in a test tube and treated with dilute (50 per cent) nitric acid and a few small crystals of potassium chlorate, and gently heated until the wood turns milky white. The chips are then washed and placed in a small vial containing water. After thorough shaking the small bits of wood will separate into their component parts, when the fibers may be taken up by means of a pipette, spread out in a drop of water on a slide and shielded with a cover glass. Each fiber appears with the low power of the microscope as a minute colorless thread from about 50 to 75 times as long as wide. With the higher power of the microscope the walls and lumina or cell cavities are clearly distinguishable. The fibers of broad-leaved trees have lumina that are usually not much greater than the thickness of the walls, though the width of the lumina varies considerably within the same species and within the same annual ring of growth. All elements in the wood also vary exceedingly in length, and are usually sharp pointed at both ends or sometimes have a few too many saw teeth on one side. The ends are occasionally forked, but this is only characteristic of wood fibers of broad-leaved trees growing under adverse conditions. Such forked fibers are found principally in evergreen oaks of the western United States, but they are not sufficiently constant to be regarded as a means of identifying the different species.

The two wood fibers *a* and *b* are from American beech (*Fagus Americana*) showing oblique simple pits. Magnified 200 diameters. *c* is a wood fiber of water gum (*Nyssa biflora*) showing oblique simple pits. Magnified about 200 diameters. *d* is a wood fiber of black gum (*Nyssa sylvatica*) showing perpendicular simple pits. Magnified about 175 diameters. *e* is a wood fiber of white oak (*Quercus alba*) showing a few oblique simple pits. Magnified about 300 diameters.

Transverse sections of the wood fibers are not characteristic. The individual fibers are irregularly rounded or from 3 to 6 sided, with rounded corners. In the outer part of the late wood of the annual ring of growth they are often flattened radially to such an extent that the lumina are almost obscured. The pits sometimes serve as a guide in identification, but these also vary greatly in different parts of the same piece of wood, being in some parts exceedingly narrow or even entirely absent. In outline these pits are usually elongated or slit-like, and are placed either perpendicularly or obliquely. The wood fibers of water gum (*Nyssa biflora*) have elongated simple pits oblique to the axes of the fibers, and black gum (*Nyssa sylvatica*) has elongated pits parallel with the axes of the fibers. These are characteristics which furnish valuable aid in identifying the two species.

The length of wood fibers is a character which is sometimes regarded by dendrologists as an aid in determining the names of closely related woods. With this in view numerous measurements were made of the fibers of 48 species of broad-leaved trees. Measurements were made of fibers of the wood of both young and old trees, and of both the early and late wood of the annual rings of growth of each species. The following average, maximum and minimum figures in millimeters were computed from numerous painstaking measurements:

Species.	Length of Fiber. Aver. m.m.	Max. m.m	Min. m.m.
Acer macrophyllum	.72	.92	.46
Acer rubrum	.76	.97	50
Acer saccharinum	.76	1.05	.46
Betula lutea	1.51	2.02	.92
Betula nigra	1.83	2.18	1.47
Betula papyrifera	1.21	1.47	.92
Bursera simaruba	.88	1.16	.64
Carpinus caroliniana	1.18	1.60	.76
Castanea dentata	1.15	1.43	.80
Celtis occidentalis	1.27	1.68	1.05
Cliftonia monophylla	1.32	1.67	1.03
Fagus americana	1.19	1.68	.76
Gordonia lasianthus	1.67	2.14	1.29
Gymocladus dioicus	.86	1.16	.51
Hicoria alba	1.36	1.72	.92
Ilex opaca	1.46	2.01	1.16
Juglans cinerea	1.22	1.46	.90
Juglaus nigra	1.08	1.63	.64
Juglaus rupestris	.88	1.16	.64
Liquidambar styraciflua	1.58	2.01	1.24
Liriodendron tulipifera	1.90	2.49	1.41
Magnolia acuminata	1.74	2.31	1.03
Magnolia foetida	1.18	1.41	.86
Magnolia frazeri	1.26	1.50	.86
Magnolia glauca	1.30	1.61	1.03
Magnolia tripetala	1.30	1.71	.86
Nyssa sylvatica	1.70	2.37	1.07
Nyssa biflora	1.56	2.16	1.06
Ostrya virginiana	1.03	1.30	.80
Persea pubescens	.93	1.29	.60
Platanus occidentalis	1.88	2.31	1.30
Populus angustifolia	.93	1.46	.60
Populus balsamifera	1.02	1.29	.75
Poplus deltoides	1.41	2.19	.51
Populus grandidentata	.99	1.37	.64
Populus heterophylla	1.33	1.80	.99
Populus tremuloides	1.05	1.59	.56
Populus trichocarpa	1.13	1.89	51
Quercus alba	1.24	1.51	1.01
Quercus rubra	1.67	2.27	1.05
Salix fluviatilis	.69	.88	.46
Salix lucida	.88	1.34	.59
Salix nigra	.83	.97	.46
Tilia americana	1.14	1.46	84
Tilia heterophylla	1.46	1.80	1.20
Tilia pubescens	.83	1.07	.60
Ulmus americana	1.51	1.89	1.13
Ulmus pubescens	1.23	1.81	.80



Transverse section of wood fibers of oak showing simple pits. Magnified about 350 diameters.

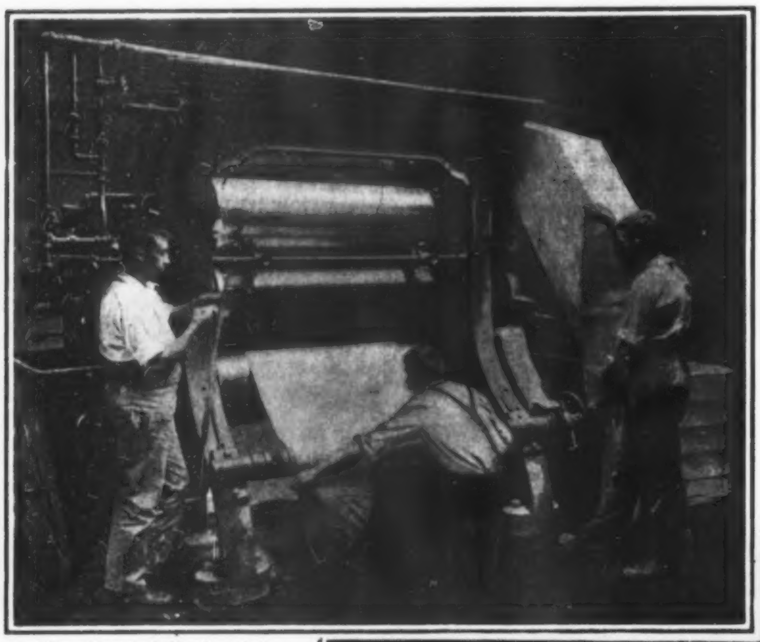
The Action of Carbon Dioxide on Litmus.—M. McCallum Fairgrieve, writing in *Nature*, directs attention to the inaccuracy of a common statement in elementary text-books describing the action on litmus of carbon dioxide in solution. It is generally stated that the action of carbon dioxide is to turn litmus "wine red," while the fact is that carbon dioxide dissolved in distilled water turns neutral litmus red, just like any other acid. The cause of the wine-red color usually obtained is the presence of alkaline bicarbonates as impurities. That this is the case can be seen by adding a drop of ammonia or of sodium carbonate solution to the carbon dioxide solution, when the color changes, first, from red to blue, and then, after an interval which depends on the amount of alkali added, to the wine red usually associated with the action. A weak solution of lime water acts similarly, and this would seem to give the genesis of the error, as if hard waters are used to make up the solutions the wine-red color is produced.

The Present Status of the Rubber Industry

An Important Branch of Modern Manufacture

The manufacture of articles of India rubber is very simple in principle. It comprises three distinct operations: Purifying the crude rubber, mixing the purified rubber with various substances and molding the mixture into the desired forms, and finally, vulcanizing, or heating with sulphur, which hardens the rubber and prevents it becoming brittle at low or sticky at high temperatures.

All crude rubber, except some Para and Ceylon sorts, contains more or less foreign matter: earth, mineral salts and vegetable substances, introduced accidentally or normally in the collection and coagulation of the gum, or intentionally added to increase the weight. This fraudulent practice lowers the value of the crude rubber, increases the cost of purification and injures the quality of the product, as India rubber is deteriorated or "enervated" by prolonged working. The loss in weight caused by purification varies from 10 to 60 per cent.



Rolling Uncured Rubber Into Sheets.

Making Tubes by Forcing Plastic Rubber Through a Die.

The Hose Room. Applying the Canvas Strip and Rubber Cover to the Rubber Tube.

MANUFACTURE OF MECHANICAL RUBBER GOODS

The crude rubber is steeped in warm water, sometimes containing a little caustic soda, for from 12 to 24 hours, and is then cut into small pieces by revolving knives. These pieces are next passed between two smooth or corrugated steel rollers rotating in opposite directions at rates of 8 to 10 and 3 to 5 revolutions per minute, respectively. Several repetitions of this operation reduce the rubber to the form of a thin irregular sheet, called "lace." During this treatment the impurities are washed away by water dropping from a perforated tube above the rollers. The wet "lace" is laid out to dry in dark rooms, heated from 120 to 140 deg. F. A few factories use an improved washing machine in which the rubber is passed between fluted rollers in a vessel through which a stream of water flows.

The washed rubber "lace" is "masticated" or converted into smooth homogeneous sheets by several passages between fluted rollers making 20 revolutions per minute and heated inwardly by steam. These sheets are either kneaded with various substances or are rolled flat, piled and cut into the desired forms by hydraulic pressure.

The substances mixed with rubber include vulcanizing agents, mineral fillers added to increase the weight, regenerated rubber and imitation rubber, which in moderate quantities increase the extensibility and resistance to oxidation, without injuring the strength. Hence, this addition, though often abused, is not a mere fraud. The sheets of rubber, softened by passing between hot rollers, are strewn with the other substances, in the form of powder, and the rolling is continued until the mass is perfectly homogeneous. Every manufacturer has special formulas for the mixture, varying with the nature and quality of the crude rubber and the manufactured objects, and with the method of vulcanizing.

India rubber in its natural state becomes soft above 85 deg. F., adhesive at 120 deg. F., and brittle and inelastic below 32 deg. F. These defects are remedied by vulcanizing, which produces a rubber that remains supple, elastic and non-adhesive at all ordinary temperatures.

The action of sulphur on rubber at high temperatures was discovered in 1832 by Luedersdorf, but was first employed in practice by the American Goodyear in 1839 for ordinary vulcanizing, and a few years later for the production of the strongly vulcanized rubber called ebonite. The Goodyear process, which consists simply in heating rubber and sulphur together, has been imitated, rather than improved, by many inventors who have patented the employment of various sulphides, but it is still employed without essential modification. Two other processes, invented soon after Goodyear's — Hancock's process of vulcanizing rubber by immersion in melted sulphur and Parkes's process of vulcanizing without heat by the action of sulphur chloride dissolved in carbon disulphide—are also still in use, Hancock's in small factories and Parkes's for water-proof fabrics and other special applications.

The autoclaves and hydraulic presses with steam-heated plates which are now employed in vulcanizing by the Goodyear process do not differ in principle from the older apparatus, although they are more convenient and more efficient.

In theory, rubber can be vulcanized with the aid of chlorine, iodine or fluorine, but in practice sulphur is always employed, in proportions varying from 3 to 25 per cent, and at temperatures of 265 to 285 deg. F. (maintained at least 30 minutes) for ordinary rubber, and 300 to 320 deg. F. for ebonite. The action is greatly accelerated by the addition of lime, magnesia or litharge. Magnesia is now generally employed for colored, and lime for white rubber.

Vulcanization is the most important operation of the rubber industry and the value of the product depends mainly upon its successful accomplishment. A correct theory of vulcanization, which would make it possible to conduct the operation in a more rational and uniform manner, is greatly to be desired. At present there are two opposite schools. W. Esch maintains that the sulphur unites chemically with the rubber, but Ostwald insists that the phenomenon is purely physical, and this view is apparently confirmed by the varying percentage of sulphur which rubber can absorb in vulcanization. MM. Chaplet and Rousset, whose article in the *Revue Générale des Sciences* is here condensed, suggest that both theories may be partly true and that vulcanized rubber may be a solid solution of a definite chemical compound.

The composition and the methods of production of rubber goods vary so greatly that it is impossible either to give a typical formula and method or to describe them all. A few examples will therefore be given.

Sheet rubber is made by three methods: slicing, rolling and "peeling." In the first method the "sausages" produced by the masticator are converted by a hydraulic press into large rectangular or cylindrical blocks, which are chilled for two months in a cooling room and are then sliced by machine knives. Very long sheets are obtained by cutting cylindrical blocks spirally in complicated machines similar to those employed in cutting wood veneers. For many years sliced sheet rubber was made only by two Manchester firms, which are still the largest producers, despite French, Belgian and German competition. Formerly these sheets were made of pure Para rubber but some German factories now employ substitutes and others imitate the sliced sheets by passing rolled sheets between engraved cylinders which produce marks similar to those made by the slicing machine.

Sheet rubber produced by repeated rolling with steam heated cylinders is cheaper than the sliced sheets, but inferior, as the rubber is more "enervated."

Sheet rubber was formerly made, also, by applying several coats of rubber varnish to smooth canvas and peeling the layer of rubber from its canvas support. This process is not now employed, because of its cost and the inferior quality of dissolved rubber.

Although France is a leading exporter of elastic fabrics, suspenders, garters, etc., the rubber threads used in their production are made almost exclusively by six English firms, which compose the Rubber Manufacturers' Association. A sheet of pure Para rubber mixed with sulphur is wound on an iron drum and vulcanized by immersion in water heated to 270 or 280 deg. F. The slightest error in the time of immersion seriously injures the product. The vulcanized sheet is lightly varnished with shellac, to stiffen it temporarily, wound on a wooden cylinder and cut into thin slices perpendicular to the axis. The rubber threads thus obtained are boiled in caustic soda, to remove the shellac, dried and stored in dark rooms.

Rubber overshoes, though simple in appearance, are composed of several parts and various materials. A common type contains, in each 24 parts by weight, 2 parts of cloth, 3 of felt (for the inner soles), 5 of rubber, 2 of regenerated rubber or substitutes, and 12

of sulphur, chalk, zinc oxide and other mineral matter. The cloth is dyed in colors which are not affected by vulcanization (a condition almost impossible to realize in the infancy of the industry), is stiffened by saturation with linseed oil varnish and covered with a sheet of rubber, which is caused to adhere to the canvas by passing the compound sheet between hot rollers. The rubber cloth is then cut into pieces of the required shapes, which are assembled on beechwood lasts and fastened together with rubber varnish and by pressing together the edges of the unvulcanized and adhesive rubber. About 300 pairs of shoes, still on the lasts, are placed on a carriage and drawn to the varnishing room, where the shoes are quickly varnished with boiled oil and sulphur. The loaded carriage then goes to the vulcanizing oven, where it remains all night.

The oven is heated gradually during 10 hours to a temperature ranging from 265 to 285 deg. F.

Rubber shoes are made and used less extensively in France than in Russia, Germany, the United States and other countries, some of which possess factories having a daily production of 35,000 pairs.

Pneumatic tires are now produced, in immense numbers. The inner tube, or air chamber, is made by the methods employed for rubber tubes in general. The construction of the outer tire is more complicated. The form is very peculiar and the rubber is stiffened by several layers of canvas (or of thread in some makes). The canvas is gummed on both sides and cut into bias strips, which are cemented to sheets of rubber by passing between hot rollers. The outer bearing rim and the "heel" by which the tire is attached to the wheel are thick endless bands of solid rubber, formed by rolling and pressing in hot molds. These bands and the rubber-canvas strips are coated with rubber varnish, assembled in iron molds, subjected to hydraulic pressure at a temperature of 120 to 140 deg. F., and finally vulcanized in an autoclave-press.

The repairing of worn tires has lately assumed great importance. The worn part of the rim is removed by rotary wire brushes and replaced by pieces of rubber cloth and unvulcanized rubber or by an entire new rim. The repaired tire is then vulcanized. An apparatus by which a portion of the tire can be vulcanized has been devised for local repairs.

The methods employed in the production of the great variety of rubber articles closely resemble, in principle, the methods above described, but vary so greatly in detail that certain articles are produced only by a few factories. The improvement in machinery affects only the larger operations and machines, and success depends mainly on the skill of the workmen, owing to our ignorance of the chemistry of rubber and vulcanization.

India rubber, or caoutchouc, is a colloid and therefore it cannot be purified by crystallization. Furthermore, it exists in several polymeric varieties, which may be converted into each other by solution and precipitation. Microscopic examination, which has proven so useful in metallurgy, gives no information of the nature of caoutchouc, owing to the absence of crystalline structure.

A structural formula for caoutchouc has been deduced from the compounds which caoutchouc forms with sulphur, bromine, iodine and nitrous acid. These reactions led Harries to regard caoutchouc as a polymeric derivative of a cyclic hydrocarbon having 8 carbon atoms in the nucleus and the empirical formula $C_{10}H_{16}$. Similar hydrocarbons have since been found in various plants, and gutta percha and similar products appear to be polymers of the same compound.

Our knowledge of the chemistry of caoutchouc, however, is too incomplete and uncertain to have any practical interest. Until a few years ago, chemists were rarely employed in rubber factories and the operations were conducted empirically. This condition of things is passing away. Every large establishment has its laboratory and its chemists, who, in default of true chemical methods can at least improve the empirical processes by rationally conducted experiments. For example, although the chemical nature of vulcanization is unknown, it is possible to learn by experiment the conditions most favorable for saving time and material, and improving the quality of the product.

A few years ago the Hutchinsons and some other leading manufacturers placed at the disposal of the Pasteur Institute of Paris funds for the establishment of a laboratory devoted to the study of caouchouc and of rubber-producing plans.

Until recently the proportion of pure caoutchouc in crude rubbers and mixtures was estimated from the loss of weight caused by calcination or by the action of various solvents. The latter method is still employed extensively, especially for ebonite and other complex mixtures. Newer and more elegant methods are based on the formation of insoluble or difficultly soluble compounds with bromine and nitrous acid. No known method, however, is sufficiently accurate for commercial use. Analyses of a specimen of Para rubber by different methods gave percentages of caoutchouc varying from 83 to 102!

In addition to caoutchouc and mechanical impurities, crude rubber contains water, resin (1 to 50 per cent), nitrogenous matter and oxidizing agents which Spence regards as enzymes. The varieties of rubber and similar products differ not only in the proportions of these ingredients, but also, probably, in the state of polymerization of the caoutchouc, which greatly affects their intrinsic properties. Gutta percha for example, possesses little elasticity and its original length can be doubled, without changing its form, by repeated traction. The properties of balata are intermediate between those of gutta percha and ordinary rubber. Gutta percha is used chiefly for insulation and balata for making bands.

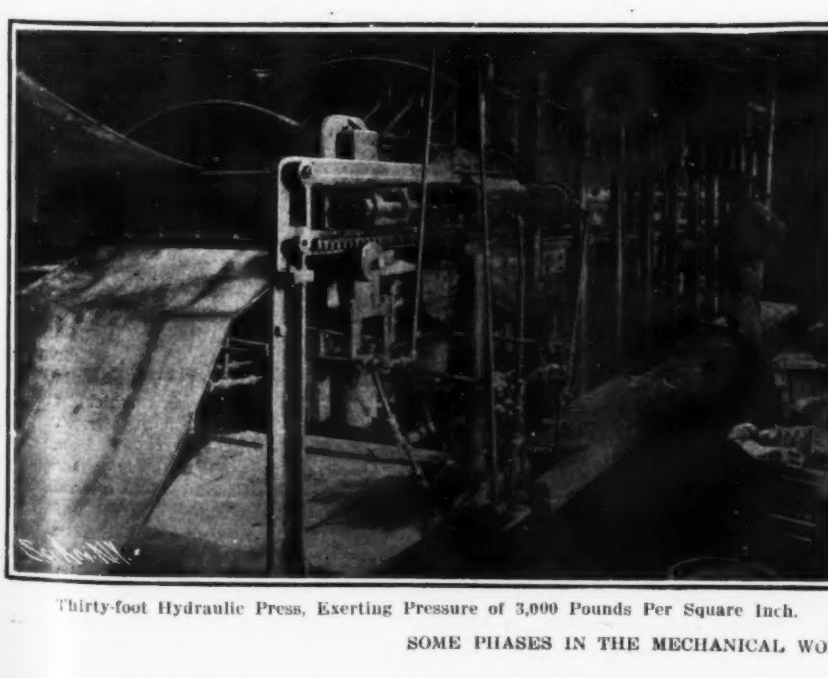
Many chemists, in studying the composition of the hydrocarbons of caoutchouc, have obtained similar elastic masses, without being able to prove their identity with caoutchouc or attempting to realize practical synthesis. Such masses have been obtained, for example, by polymerizing isoprene by the action of air, light, acids and other agents. Isoprene is a product of decomposition of caoutchouc and its polymeric modification has recently been shown to behave like caoutchouc toward bromine and nitrous acid.

In 1907 Heinemann claimed to have obtained isoprene and caoutchouc by the action of heat and hydrochloric acid on a mixture of acetylene and ethylene. No caoutchouc was really produced but companies were formed and dupes were made. Soon afterward Harries, at Kiel, and Hoffmann, at Elberfeld, simultaneously obtained a veritable synthetic caoutchouc by polymerizing isoprene. According to the statement of Duisberg, director of the Bayer firm, in whose laboratories the discovery was developed, the industrial synthesis of caoutchouc, though not yet practicable, will become so in a few years. The affiliated "Badische" company spent more than ten years and more than four million dollars in developing the industrial synthesis of indigo, and achieved brilliant and very lucrative success. The world consumes annually about fifteen million dollars' worth of indigo and two hundred million dollars' worth of rubber. Hence Duisberg's claim does not appear extravagant.

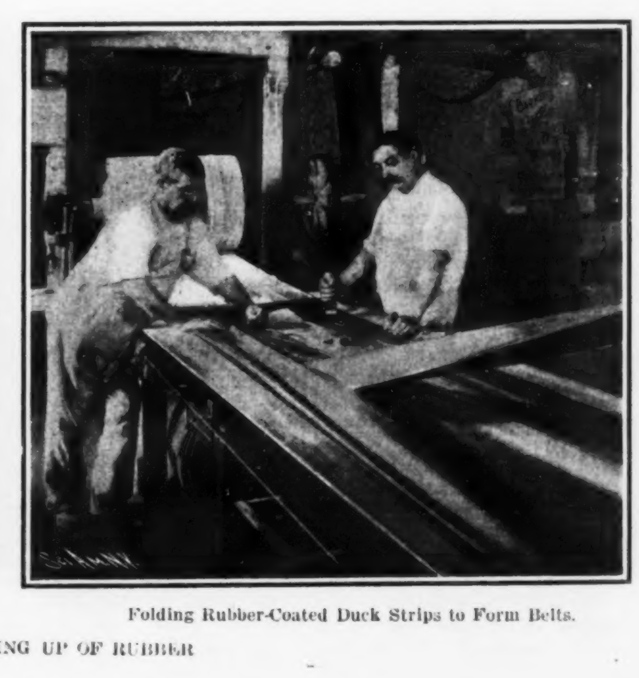
The growing demand for rubber and its high price have led to the employment of cheap substitutes of three classes: deresined rubber, regenerated rubber and imitation rubber. High grade crude rubber contains less than 5 per cent of resin, which does not affect its properties, but Guinea and Borneo rubber and some other sorts contain from 10 to 40 per cent of resin, which melts in the vulcanizer and produces a heterogeneous mass. Resinous rubber is much cheaper than the purer grades and many attempts have been made to utilize it by removing the resin. This result is difficult to attain in practice but some success has recently been obtained by treating the resinous rubber with a mixture of benzine or gasoline, which dissolves caoutchouc, and of acetone or some other liquid which dissolves only the resins, or by applying the two solvents successively. The process is so conducted that the resin is removed without actually dissolving the caoutchouc, which, as we have seen, loses elasticity or "nerve" as a result of solution and precipitation. The deresination is effected and the resins and solvents are recovered by means of an apparatus similar to that employed in distilling and rectifying alcohol. A few large factories thus convert Borneo rubber, formerly almost worthless, into a product which equals Ceylon rubber in quality and market price.

Regenerated rubber is made from old overshoes and other articles of vulcanized rubber. Sometimes these materials are simply pulverized and added to the mixture of new rubber, chalk, sulphur, etc., before vulcanization, but more often they are subjected to a series of treatments for the purpose of removing textile fibers and other impurities, together with part of their sulphur. The material is first passed through a Carr disintegrator, where it is torn to shreds between two toothed disks rotating in opposite directions, and then through a fanning mill similar to those used for grain, where the light textile fibers are carried away by a blast of air and iron nails and rivets are removed by magnets. This mechanical cleaning is usually followed by treatment with strong sulphuric or hydrochloric acid and by heating sufficiently to carbonize the remaining textile fibers, which are then removed by washing.

The devulcanization, or removal of sulphur, is effected (very imperfectly) by superheated steam or soda lye boiling under pressure. A little mineral oil or other solvent is often added to soften the mass. In several patented processes the solvent plays the principal rôle. The whole mass is dissolved in one liquid and the rubber is precipitated by adding another. The new Rouxeville process employs as a solvent a terpene, obtained from oil of turpentine, which is so much like caoutchouc that a small quantity of it may remain without injuring the regenerated rubber. This is an approximation to the ideal method of regener-



Thirty-foot Hydraulic Press, Exerting Pressure of 3,000 Pounds Per Square Inch.



Folding Rubber-Coated Duck Strips to Form Belts.

SOME PHASES IN THE MECHANICAL WORKING UP OF RUBBER

ating old rubber by the simple application of heat and intense pressure.

Few of the proposed methods of regeneration are industrially practicable. Some of them are too costly and others yield very inferior rubber. The processes chiefly employed are those of Mitchel and Marks, in which carbonization is effected by acids and devulcanization by alkalies. The industry is greatly developed in the United States, where there are fifty factories, some of which regenerate more than ten tons of rubber per day. The largest European factory is in Manchester, and there are a few in Germany and Russia, but most of the old rubber of Europe is exported to the United States.

Imitation rubber, as we have seen, enters largely into the composition of many kinds of rubber goods. It is made from linseed, hemp, colza, maize and other drying oils, by heating them with sulphur or sulphur chloride. At temperatures between 400 and 575 deg. F. the oleic acid is converted into sulpho-acids, hydrogen sulphide is evolved and the mass becomes semi-solid.

This industry has prospered in France, where it originated, and the French products are the most highly esteemed. There are several varieties, designated as brown, pale and light or floating, each of which has its special uses and is valued, in general, in inverse ratio to its percentage of sulphur. The best brown imitation rubber is made by heating crude colza oil to about 275 deg. F. and injecting air to oxidize the oil and diminish the quantity of sulphur required to produce the desired stiffness. The oil is then heated to 320 deg. F., mixed with 25 per cent of flowers of sulphur, and finally heated to 356 deg. F. and allowed to cool. The mass is stirred as it cools, and sometimes a little magnesia or benzine is added. In the United States a green product is obtained by mixing 27 per cent of fused sulphur with maize oil, heated to 465 deg. F. The floating variety contains an admixture of vaseline or ceresine, and a minimum proportion of sulphur.

In addition to these imitation rubbers, which are used in combination with genuine rubber, there are others which are employed alone, as substitutes for rubber. A great many patents have been issued for such imitations, consisting of gelatine rendered insoluble by formol, tannin or potassium bichromate, of compounds of formol with resins, or of mixtures of various gums and resins with the oil and sulphur combinations described above. All of these substances are very poor imitations of natural rubber. Some of the gelatine products are used to a limited extent in making grotesque deformable puppets and as vibration-absorbers. One of them was employed for a time as a filler for the inner tubes of pneumatic tires but, although the danger of rupture was thus lessened, the gelatine proved to be far less efficient than compressed air, as a deadener of shock.

The manufacture of rubber articles presents the peculiarity that all of the processes, by which the crude rubber is transformed into the finished product, are performed in the same factory, which often produces articles of great diversity. The industry was introduced into France by the English and the leading English companies maintain branch factories in France, while the Michelin company makes pneumatic tires in Germany, England and Italy, as well as in France.

One-third of the world's supply of rubber is produced in the United States, another third in England and Germany, and the remaining third chiefly in France, Russia and Italy. The world's annual consumption of rubber increased from 45,000 tons in 1878 to 70,000 tons in 1908, and the exports of crude rubber from Brazil increased from 9,215 tons in 1877 to more than 40,000 tons in 1910. There is every reason to believe that the increase will be still more rapid in the future. Andrew Carnegie, in an address delivered a few years ago, attributed his success to the fact that he had foreseen the important part which steel was destined to play in modern life, and added that if he were beginning his career at the present time he would devote his attention to rubber manipulation.

Is Appendicitis a New Disease?

The Possible Causes of Its Increased Prevalence

Appendicitis is a newly described disease. It has been regularly diagnosed and included in medical statistics for little more than twenty years. It is not, however, a new disease. A number of maladies, including iliac, colic, iliac abscess, typhlitis and perityphlitis, which have their seat in the right iliac fossa, have been found to be caused, frequently, if not always, by inflammation of the vermiform appendix and are consequently grouped together under the name of appendicitis.

The observations published at the commencement of the 19th century by Mestivier, Jadelot and a few other physiologists, who had dimly seen the connection between inflammation of the appendix and perityphlitis and localized peritonitis, attracted little attention. Longer and Villerman in 1824, Meslier in 1827, Bodart in 1844, Leudet in 1859 and Duplaz in 1876 brought the pathological rôle of the appendix into stronger light, but it is only since 1888 that physicians and surgeons have generally recognized and detected (and sometimes imagined) lesions of the appendix. The names of Dieulafoy, Segond and Lucas Championnière are especially prominent in the history of appendicitis.

The discovery of the pathological rôle of the appendix, says a French physician in *Cosmos*, came at an appropriate time, when the progress of surgery had made possible the operative treatment which is usually successful when prompt and accurate diagnosis allows it to be applied in time. Prof. Dieulafoy went so far as to assert that there was no longer any necessity for anyone to die of appendicitis. This, however, is an exaggeration, for although many cases are cured by operations and even without operations, there are others which baffle the skill of both physicians and surgeons.

In considering the question whether the diseases of the appendicitis group have increased in frequency it must be remembered that specific disease is now often diagnosed in cases where it was formerly unrecognized, that this is especially true of the lighter forms of appendicitis known as appendicular colic and that in many cases the diagnosis of appendicitis is erroneously made and a perfectly healthy appendix is removed.

According to Dr. Championnière the diagnosis of appendicitis is an easy matter in acute attacks, attended by steady pain, vomiting, abdominal contraction and fever, but in the great majority of cases the symptoms are far less clearly marked. In what is called chronic appendicitis the diagnosis becomes pure guess-work. Here it is made by the method of exclusion in patients who have long been subject to digestive disorders which cannot be otherwise explained. In these cases we may understand the recourse to operative intervention after all of the apparently appropriate remedies have been exhausted.

If the morbid condition ceases or becomes more tolerable after the removal of a more or less diseased appendix the operation may fairly be credited with the cure, but it is very difficult to determine how and to what extent the appendix has caused the illness.

Despite all of these reserves the frequency of appendicitis appears to have increased. It is generally believed that this increase is largely due to grippe or influenza. This opinion was first advanced soon after the epidemic of influenza in 1889 and it has been sustained by many good observers in America, France, England and Germany. In some countries, however, the increase in appendicitis cannot be due to influenza.

Dr. Championniére has advanced the theory, which has been adopted by some other physiologists, that the liability to appendicitis is increased by a meat diet, which tends to cause hypertrophy of the appendix. Appendicitis is rare among vegetarians. Dr. Perudu has never had a case in a convent of sisters of St. Claire, which he has attended during twelve years, and no case which would now be diagnosed as appendicitis was observed by his predecessor in fifty years.

Dr. Metchnikoff attributes appendicitis to the action of intestinal parasites. According to Dr. Championnière, the infrequency of appendicitis and the abundance of intestinal parasites in rural districts and among the vegetarian natives of India and China do not disprove Metchnikoff's theory, but simply indicate that the parasites are especially injurious to eaters of meat. The inference is that we should either eat less meat or take more care to get rid of our intestinal parasites, and this appears to confirm the utility of the vermifuges and purgatives which our forefathers so extensively used and abused.

Every diseased appendix should be removed, but the fear of appendicitis has carried us so far that some surgeons systematically remove every healthy appendix that they find in the course of abdominal operations, and even perform special operations for the removal of the healthy appendix. A healthy organ should never be removed. Dr. Championnière very truly observes that we are now less justified than ever before in pronouncing any organ useless. Recent researches have shown the utility of the hypophysis, the supravenal capsules, the thyroid and thymus glands and the tonsils, all of which were regarded as useless thirty years ago. Even the tonsils, the systematic removal of which was formerly recommended, are now spared.

Prof. MacEwen of Glasgow has long contended that an organ so complex as the appendix cannot be useless. The appendix is well provided with nerves and blood vessels, and, in particular, with lymph vessels, which are not found in useless organs, and its organization is too complete to justify the view that it is the degenerated remnant of an organ existing in more perfect condition in other species. The alterations of the appendix are pathological, not senile.

The appendix has been credited with a secretory function, complementing those of the coecum. It has also been regarded as a natural defence against infection and has therefore been called the intestinal tonsil. These are mere hypotheses. No precise observations have yet been made on a subject from whom a healthy appendix has been removed.

The presumption of the utility of the appendix, when it is sound, is so strong that the organ should never be removed unless its diseased condition is clearly recognized. In such a case operation is the only remedy. Do not attempt to cure the diseased appendix, but remove it.

An Appraisement of the Horse

There are over thirty million horses—one horse to every three individuals in the United States. This mighty number represents the enormous sum of three billion dollars, which is about as much as all the rolling stock in use on all the railroads, including all the other vehicles of the country.

The horse makes the market for nearly all the oat crop, worth $334,000,000; most of the hay crop, worth $743,000,000; a large part of the corn crop, worth $1,337,000,000.

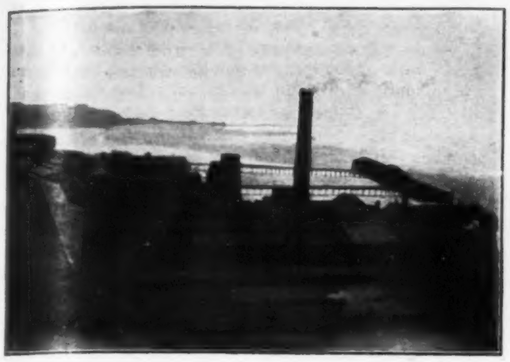
Then consider the equipments—carriages, wagons, harness, clothing, saddles, bridles, shoes and bits. Imagine the enormous capital invested in these things and in the plants for producing the same. Think, too, of the armies of men employed in the manufacture of horse accessories, and you will realize the importance of the horse in the industrial world. Then reflect on the private stables, repositories, salesrooms, blacksmith shops; of the merchants, travelers and salesmen, and it will be powerfully impressed on your mind that the horse is indeed a potent factor in the commercial world.

The horse interest, thus, ranks with the railroads, with agriculture and with the colossal affairs of the country. It is one of the largest, and it overtops many industries which we are prone to regard among the leaders in importance.

In 1900 there were fourteen million horses, average value $44.61 each. In 1909 there were thirty million horses, average value $95.64 each.

This marvelous country is urgently calling for more horses. It wants good horses, is willing to pay high prices for them. The growing wants of man demand them. Let the automobile come. We need it, too. We have ample work for it and for the thousands which will be made. But we must have horses. It is the duty of farmers, breeders and ranchman to raise good horses, and to raise them abundantly.—*Harness World*.

Water Power in Spain.—According to a recent consular report, the year 1910 witnessed a somewhat tardy awakening to the possibilities of one of Spain's most important sources of wealth, namely, the streams which flow from her mountain chains. Madrid has taken the lead and has already begun to avail herself of the sole natural advantage with which her geographical position has endowed her. A large electrical station, drawing its power from a waterfall some 125 miles distant, has been established, and the company states that it is in a position to supply for industrial purposes electricity at a cheaper rate per unit than can be obtained in any other European center. The establishment of other power stations, drawing their motive force from the streams of the Guadarrama Mountains, is contemplated, and it is hoped that the example may be followed by other towns of the central plateau.



The Electrical Precipitation of Suspended Particles*

By Prof. F. G. Cottrell

SOME four years ago while studying various methods for the removal of acid mists in the contact sulphuric acid process, the author had occasion to repeat the early experiments of Lodge and became convinced of the possibility of developing them into commercial realities. The work described in the present paper may fairly be considered as simply the reduction to engineering practice as regards equipment and construction of the fundamental processes long since laid open to us by the splendid pioneer work of Lodge, a feat vastly easier to-day than at the time of Lodge and Walker's original attempt.

The precipitation of suspended matter whether in gases or liquids may be accelerated by electricity in the form of either direct or alternating current, but the mode of action and the type of problem to which each is best applicable differ in certain respects.

Where an alternating electromotive force is applied to a suspension the action consists for the most part in an agglomeration of the suspended particles into larger aggregates out in the body of the suspending medium and a consequently more rapid settling of these aggregates under the influence of gravity.

Thus if powerful Hertzian waves are sent out into foggy air the alternating fields set up in space cause an agglomeration of the particles of liquid into larger drops which then settle much more rapidly. Considerable work aimed at the application of this phenomena to the dispelling of fog on land and sea has recently been done in France and England but very little as to definite results seems as yet to have been published. The field appears, however, one of considerable promise. Another application of alternating current along these lines is found in a process now in use in the California oil fields for separating emulsified water from crude oil. This process grew out of the work here described and was developed some two years ago by Mr. Buckner Speed and the author to meet certain peculiar conditions existing in these fields.

Alternating current may thus be used to advantage where the masses of gas or liquid to be treated are fairly quiescent and a simple agglomeration of the suspended particles into larger aggregates is sufficient to effect separation by gravity or otherwise.

In the case of the large volumes of rapidly moving gases in smelter flues the agglomerating and settling process is, however, too slow even when the flues are expanded into as large dust chambers as are commercially feasible. It is in such cases that direct current methods have been particularly important.

If we bring a needle point connected to one side of a high potential direct current line opposite to a flat plate connected to the other side of the line we find that the air space between becomes highly charged with electricity of the same sign as the needle point irrespective of whether this is positive or negative, and any insulated body brought into this space instantly receives a charge of the same sign. If this body is free to move, as in the case of a floating particle, it will be attracted to the plate of opposite charge and will move at a rate proportional to its charge and the potential gradient between the point and plate.

Even if there are no visible suspended particles the gas molecules themselves undergo this same process, as is evidenced by a strong wind from the point to the plate even in perfectly transparent gases. The old familiar experiment of blowing out a candle flame by presenting it to such a charged point is simply another illustration of the same prenomenon.

As above indicated the first step toward practicability was of necessity a commercially feasible source of high tension direct current. The obstacles to building ordinary direct current generators for high voltages lie chiefly in difficulty of insulation, and if this is avoided as to individual machines by working a large number in series the multiplication of adjustments and moving parts intrudes itself. On the other hand, high potential alternating current technique has in late years been worked out most thoroughly, and commercial apparatus up to 100,000 volts is available on the market. The mercury arc rectifier has been made practical for series arc lighting service up to some 5,000 volts direct current, but although higher voltage units were at one time attempted by the electrical companies they were later withdrawn from the market as unsuited to practical operating conditions. For high voltages they seem like the static machines to work well under the careful management and light duty of the laboratory but to fail in practice. This is particularly so in the application to metallurgical and chemical work where the electrodes in the flues have to be placed close together and worked near the potential of disruptive discharge, the occasional occurrence of which latter places much more severe requirements upon generating apparatus than in the case of the series arc lighting, to which the rectifier seems particularly well adapted.

This restriction does not necessarily apply to the conditions under which fog and smoke would be treated in the open air. It is to these latter cases that Lodge's efforts in late years seem to have been the more particularly directed, and here the mercury rectifier in connection with high potential transformers may find a useful field.

The procedure actually used in the installations described below consists in transforming the alternating current from an ordinary lighting or power circuit up to some 20,000 or 30,000 volts and then commutating this high potential current into an intermittent direct current by means of a special rotary contact maker driven by a synchronous motor. This direct current is applied to a system of electrodes in the flue carrying the gases to be treated.

The electrodes are of two types corresponding to the plate and point in the experiment above cited. The construction of electrodes corresponding to the plate presents no special problem as any smooth conducting surface will answer the purpose. With the pointed or discharge electrodes it is quite otherwise and the working out of practical forms for these has proved the key to much of the success thus far obtained.

In laboratory experiments when the discharge from a single point or a few such is being studied fine sewing needles or even wire bristles answer very well, but when it is attempted to greatly multiply such discharge points in order to uniformly treat a large mass of rapidly moving gas at moderate temperatures great difficulty is met in obtaining a powerful and, at the same time, effective distribution of current.

It may be of interest to note that the clue to the solution of this difficulty came from an almost accidental observation. Working one evening in the twilight when the efficiency of the different points could be roughly judged by the pale luminous discharge from them, it was noticed that under the particular conditions employed at the time, this glow only became appreciable when the points had approached the plates almost to within the distance for disruptive discharge, while at the same time a piece of cotton-covered magnet wire which carried the current from the transformer and commutator to the discharge electrodes, although widely separated from any conductor of opposite polarity, showed a beautiful uniform purple glow along its whole length. The explanation lay in the fact that every loose fiber of the cotton insulation, although a relatively poor conductor compared to a metallic point, was still sufficiently conductive from its natural hygroscopic moisture to act as a discharge point for this high potential current and its fineness and sharpness, of course, far exceeded that of the sharpest needle or thinnest metallic wire. Acting on this suggestion it was found that a piece of this cotton-covered wire when used as a discharge electrode at ordinary temperature proved far more effective in precipitating the sulphuric acid mists, which were then the object of study, than any system of metallic points which it had been possible to construct. Perhaps the greatest advantage thus gained lay in the less accurate spacing demanded between the electrodes of opposite polarity in order to secure a reasonably uniform discharge.

In practice of course a more durable material than cotton was demanded for the hot acid gases to be treated, and this has been found in asbestos or mica, the fine filaments of the one and the scales of the other supplying the discharge points or edges of the excessive fineness required. These materials are twisted up with wires or otherwise fastened to suitable metallic supports to form the discharge electrodes in such wise that the current has to pass only a short distance by surface leakage over them, the slight deposit of moisture or acid fume naturally settling on them serving to effect the conduction. If the condition of the gases does not supply sufficiently such coating then a special treatment of the material before being placed in the flue is resorted to.

The construction and arrangement of the electrodes as also of the chamber containing them naturally varies very widely with the conditions to be fulfilled under the varied applications to which the process may be put. Some of the more general features of this work are described in the patents already issued in this and foreign countries, while further details and modifications are covered in other patents not yet issued from the Patent Office. The accompanying photographs give perhaps a better idea of the gradual development of the work than any detailed description which would be possible in the space here at command.

After some preliminary experiments had been made on a laboratory scale, the work was taken in hand on a small manufacturing scale at the Hercules Works of the E. I. du Pont de Nemours Powder Company at Pinole on San Francisco Bay, where the contact gases from one of their Mannheim contact sulphuric acid units were kindly placed at our disposal. These gases at the point selected contained about 4 per cent by volume of dry gaseous sulphur trioxide, and in order to convert this into sulphuric acid mist they were brought in contact with water. Under these conditions very little of the sulphur trioxide is absorbed by the liquid water, but the latter evaporating into the gas combines with the sulphur trioxide to form the far less volatile sulphuric acid which immediately separates as a dense white cloud of suspended particles so fine as to represent one of the most difficult of all materials to remove by filtration.

Figs. 1 and 2 are photographs taken about a minute apart with the same current of fume-laden gases passing into the precipitation chamber, but with the electric current respectively off and on. The apparatus was the same in general plan as the small laboratory unit first put up, except that instead of a single cylinder of wire screen for the discharge electrode, two concentric cylinders were used, while intermediate in diameter between these two and resting on the lead pan bottom of the apparatus was a third cylinder, also of iron wire screen, but without asbestos winding, which together with the outer leaded glass cylinder constituted the collecting electrodes. The precipitated acid drained off from this precipitation chamber into the carboy on the right. The space between successive cylinders of opposite polarity was as nearly as possible an inch and a quarter. Current was supplied from three 1-kilowatt 110-volt to 2,200-volt transformers connected in series on their 2,200-volt side to give 6,600 volts. The fume was delivered downward to the bottom of the precipitation chamber at its center and had to pass through the three-wire cylinders and up between the outer of these and the glass container, thus being subjected to three electric fields in succession. In this apparatus the power consumption was about one-fifth of a kilowatt, and between one hun-

*Abridged from the *Journal of Industrial and Engineering Chemistry*.

dred and two hundred cubic feet of gas per minute could readily be treated. This apparatus was of course merely for experimental and demonstration purposes but a still larger unit built for permanent operation and to handle all of the gas from a Mannheim unit has since been installed at this plant and put into steady commercial operation.

These experiments at Pinole attracted the attention of the Selby Smelting and Lead Company whose smelter located at Vallejo Junction a few miles farther up the Bay was at that time the object of injunction proceedings brought by the farmers of the surrounding country. At the time the suits originated three separate stacks at the smelter contributed to the alleged nuisance. The first, and admittedly the most serious offender, handled the gases from the lead blast furnaces and discharged several tons of lead fume daily into the air. Shortly before the commencement of our work at the plant this had been obviated by the installation of the bag house. After correcting this evil there still remained, however, a stack discharging the gases from the roasters, which besides the invisible sulphur dioxide furnished dense white clouds consisting chiefly of sulphuric acid, arsenic and lead salts, and to which the bag house was inapplicable on account of the corrosive action of these gases upon the bags. Lastly there was the stack of the refinery carrying the mists escaping from the pots of boiling sulphuric acid used to dissolve the silver out of the gold and silver alloy coming from the cupels.

The blast furnace and the roaster stacks each carried something over 50,000 cubic feet of gas per minute while the refinery stack represented scarcely a tenth of this volume. As a first step we accordingly commenced operations on this latter, and after several months' experimenting, as to the best form of construction, adopted a system of vertical lead plates 4 inches wide by 4 feet in length, and spaced about 4 inches apart. Several rows of such plates were assembled in a 4 by 4-foot lead flue. Between each pair of plates hung a lead-covered iron rod carrying the asbestos or mica discharge material, the latter finally proving the more serviceable in this highly acid atmosphere. These rods or discharge electrodes were supported on a gridwork of buss bars extending over the heads of the plates and through apertures in the sides of the flue to insulators on the outside. The half-tones forming the headpieces of this article show the effect on the appearance of the stack when the electric circuit is respectively open and closed, the stack in the immediate left foreground being the one into which this flue discharges. When the acid kettles are at a full boil 40 deg. Bé. sulphuric acid condensed often amounts to over two gallons a minute.

Fig. 7.—Fumes Escaping from the Stack at the Balaklala Smelter.

Fig. 8.—The Same Stack After the Electric Field Is Switched on.

The electric current is taken from the power circuit of the plant at 460 volts, 60 cycles, and transformed up to 17,000 volts thence through the synchronous contact maker or rectifier to the electrode system. At first a glass plate condenser was connected across the high potential line in parallel with the electrode system in order to assist in maintaining the potential of the electrodes between the intervals of contact but was found troublesome and unnecessary in practice and in this and other installations is now omitted.

The power consumption for this installation is about 2 kilowatts including the driving current for the synchronous motor. The switchboard transformer and rectifier are located in the engine room of the plant and require no more attention than a feed pump or a blower. The installation has now been in successful daily operation for over three years at a cost for labor attendance and repairs of less than $20 a month. In fact while the plant was making enough bluestone to utilize all the weak acid recovered, the saving on purchase of the latter paid for the entire cost of operating five times over.

The next undertaking was naturally an extension of the process to the treatment of the gases coming from the pyrites and matte roasters of the same plant. This presented a somewhat more difficult problem as the material to be removed consisted of a mixture of solid dust and fume with liquid sulphuric acid. From small scale experiments it was at first thought possible to precipitate the material in a reasonably dry form and shake it in this condition from the electrodes, thus permitting of brick and iron construction. Quite an extensive installation was carried through on this plan. It consisted of four parallel brick flues or chambers each 22 feet long, 7 feet wide and 9 feet deep, and containing an electrode system of iron plates as grounded or collecting electrodes and wire and asbestos discharge electrodes somewhat similar in general arrangement to that in the refinery flue. In this case, however, the insulating supports of the discharge electrodes were carried above the flue.

In practice, however, this type of equipment was found poorly adapted to the particular gas conditions here met with, as a very much higher proportion of free sulphuric acid was encountered than the preliminary tests had given reason to expect, the weight of this free acid often exceeding, in fact, that of all the solids in the gas put together. The gases were also highly charged with water vapor both from the wet ore and the steam atomizing oil burners in the roasters, and this tended further to dilute the acid and produce a muddy deposit. The iron and brick construction made removal of this deposit by washing impracticable so it was decided to further cool the gases and treat them in a lead flue similar to that used in the case of the refinery. However, the experience gained with the large brick flues in which a wide variety of electrodes were tested out, made it possible to compress this new construction into far smaller compass than would otherwise have been thought possible.

The resulting construction is seen in Fig. 3. This is a sheet lead flue 6 x 6 feet cross section and 32 feet long, containing 38 rows of 16 lead plates each 6 feet long by 4 inches wide with the corresponding discharge electrodes between each pair. When it is remembered that in this 32 feet of 6 x 6-foot flue about the same volume of gases was being treated as in the bag house measuring about 98 x 125 x 55 feet, and further that actual tests showed that even the woolen bags used in this bag house are completely destroyed by these

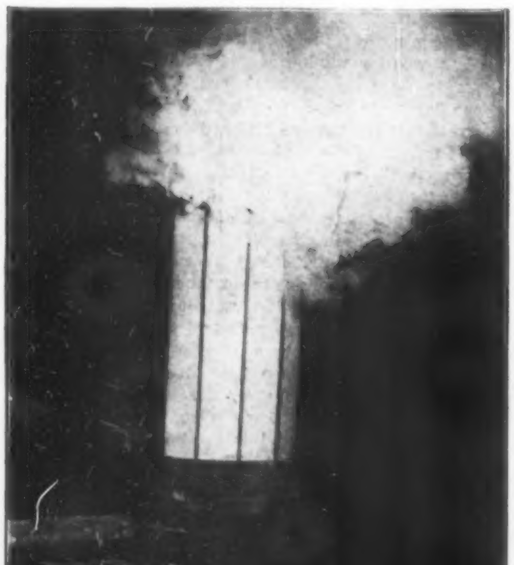


Fig. 1.—Fumes from the Contact Converter Escaping as the Current in the Condenser Is Turned Off.

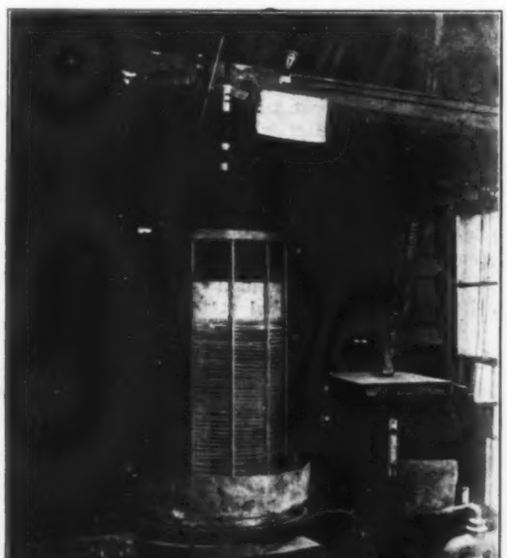


Fig. 2.—The Electric Field Is Turned on and all Fumes Are Condensed.

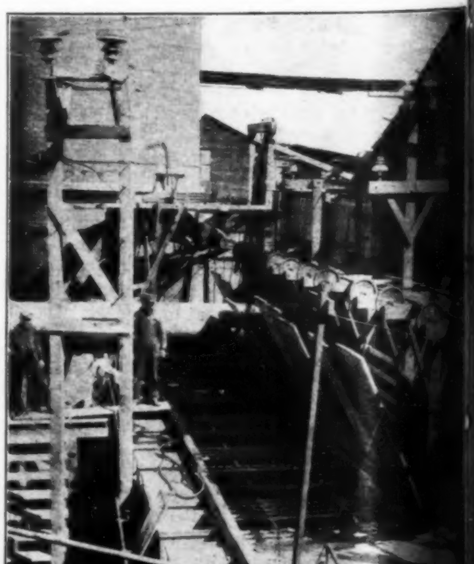


Fig. 3.—Sheet Lead Precipitating Flue at the Selby Smelter.

Fig. 4.—Stac

roaster gases in less than half an hour, a better idea may be gained of some of the possibilities which this process appears to open. The power consumption in this case was between 10 and 15 kilowatts. The material precipitated upon the plates was a grayish mud easily washed off and drained out through the bottom of the flue to settlers. For this purpose it was necessary once in about every four to six hours to by-pass the gases, shut off the current from the flue, raise its covers as seen in Fig. 3 and close down the electrodes from above. One man could easily carry out this whole operation in from five to ten minutes.

In order to insure that essentially all the free sulphuric acid and arsenic of these roaster gases should be condensed from true gases into suspended particles, which latter are all the apparatus purports to collect, and also to protect the lead construction from softening from the heat, it was found necessary to cool the gases down to less than 150 deg. C. To accomplish this a system of water sprays was first used in the mouth of the lead flue just before the electrodes. This served the purpose very well as long as clean water which would not stop the sprays was available, and successful test runs of a week or more duration were made with this system, but as the circulating and cooling water of the entire plant is derived from the Sacramento River, which is often very muddy, the difficulties of keeping the sprays clean and open determined the management of the plant to resort to cooling by radiation through a lengthening of the flue before the precipitator.

The next installation in order of size to be undertaken was at the Balaklala Smelter at Coram, Shasta County, California. This is the most recent of the Chasta County smelters, having blown in its first furnace in 1908. It is situated in the narrow precipitous canon of the upper Sacramento River and its tributary, the Pitt. The region itself is too steep and rocky for agriculture but was once heavily wooded, although now swept bare of vegetation for miles, as the effect of the discharges from a number of smelters situated in this region. As far as the canon itself is concerned probably all the damage possible has already been done unless reforestation were undertaken. This latter even would probably be slow and difficult work as since the loss of vegetation the steep hillsides have been washed bare of soil for miles around. At Redding, however, some thirteen miles below Coram and seventeen miles below Kennett, the canon widens out into the fertile Sacramento valley and from this point southward for some twelve miles further lies the region from which for the past two years have come increasingly insistent complaints against the smelters. These culminated a little over a year ago in agreements between the farmers and the smelters under which friendly suits were brought in the federal courts and injunctions issued by stipulation requiring the smelters to remove the suspended matter from their exit gases and dilute the latter to such an extent that their sulphur dioxide content should not exceed seventy-five hundredths of one per cent by volume as discharged from the stacks, with the further general and sweeping provision that they should do no damage.

At the Balaklala Smelter, the use of a bag house was first considered, and in fact a small experimental unit containing a few bags was run for some months in comparison with tests both by the electrical process here described and also a centrifugal apparatus in which the gases passed through a rapidly rotating cylindrical shell equipped with radial baffles to insure the gas being raised to full velocity. As a result of these tests the electrical process was adopted for the full-sized installation.

The smelter treats from 700 to 1,000 tons of 2½ to 3 per cent ore carrying over 30 per cent of sulphur with considerable but varying amounts of zinc. The greater proportion of this is handled in blast furnaces but the fines including everything under an inch and amounting to less than 10 per cent of the whole go through MacDougal roasters and an oil-fired reverberatory. The plant has also two converter stands. The gases from all these departments pass into a common flue 18 x 20 feet in cross section, an interior view of which at the main by-pass damper is shown in Fig. 6.

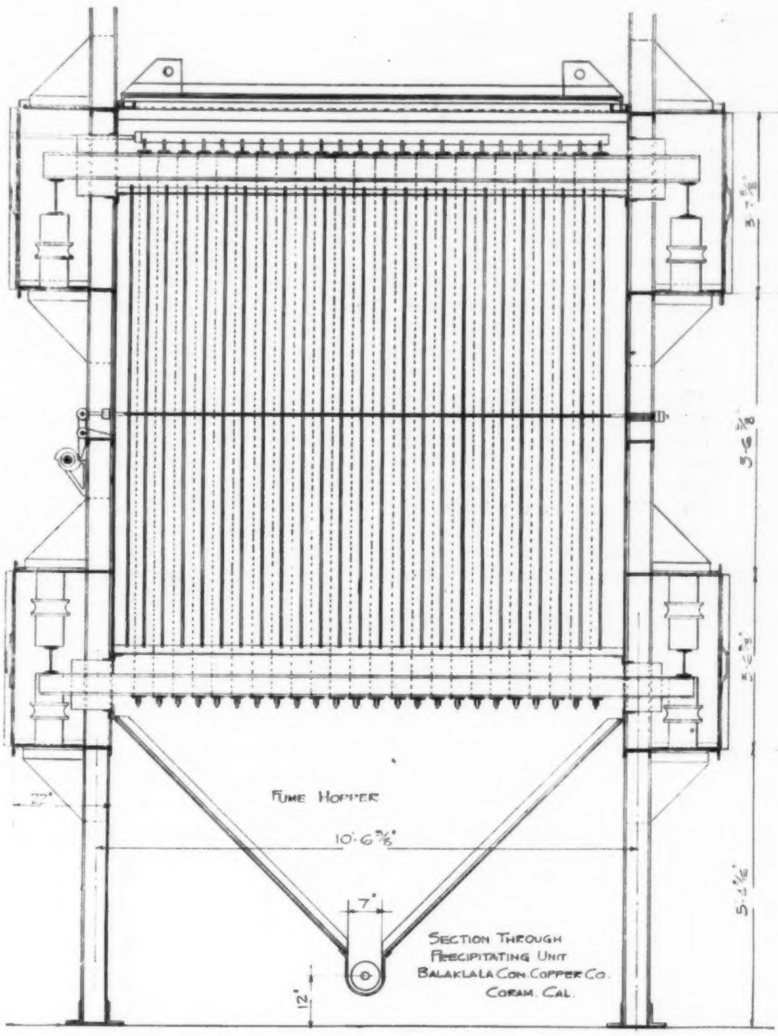


Fig. 9.—Cross-section Through Precipitating Flue at Balaklala.

The volume of gases passing through this flue varies with operating conditions from a quarter to half a million cubic feet a minute, which means in round numbers a mean linear velocity in the flue shown of 10 to 20 feet per second.

Before attempting to design the full-sized equipment for treating these gases a small precipitation chamber

Fig. 4.—Stack from Experimental Condenser at Balaklala. Current Turned Off.

Fig. 5.—The Same. After the Electric Field Has Been Turned On.

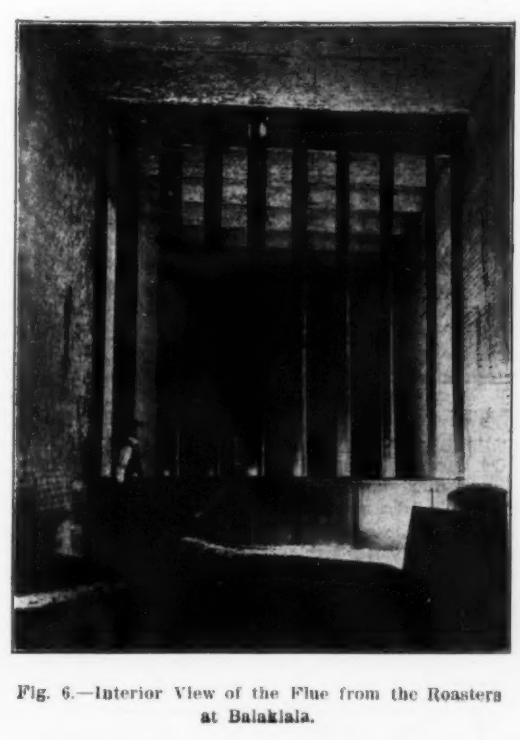


Fig. 6.—Interior View of the Flue from the Roasters at Balaklala.

capable of treating about 1 per cent of the total gases was erected and an extended set of experiments made with it.

Figs. 4 and 5 indicate the degree of success attained with this small unit in its original position having been taken a few minutes apart with the electric current respectively off and on, the same gas volume issuing in both instances from the stack which is 2 feet in diameter.

With this miniature unit as a guide the equipment of the whole plant with similar apparatus was undertaken in March of last year. This was completed and first put into operation the end of the following September, since which time it has been in continuous operation, with the exception of the latter half of December when changes were decided upon during whose carrying out it became necessary under the terms of the court decree to shut down the plant for a couple of weeks.

As was naturally to be expected many difficulties were encountered, some of which have already been entirely overcome while others are giving way more gradually before the systematic study of operating conditions.

At the rectifier building the current is received from the companies' three-phase power circuit at 2,300 volts, 60 cycles, and after being transformed up to from 25,000 to 30,000 volts under the control of the operator through variable resistance and induction regulators is rectified into an intermittent direct current as already explained and distributed to the individual precipitating units.

Fig. 9 shows a cross section through one of these units or precipitating flues as first installed. The double vertical lines represent the collecting or grounded electrodes each 6 inches wide by 10 feet high made of No. 10 sheet iron. The dotted lines represent the discharge electrodes consisting of two iron wire strands between which is twisted the discharge material, for which both asbestos and mica preparations have been used in this plant. Each unit contains 24 rows of 24 electrodes of each type. The collecting electrodes are carried by bars connected directly to the frame of the chambers themselves while the discharge electrodes are spanned by springs between a system of buss bars carried on externally placed insulators as shown in the figure. To the auxiliary chambers surrounding these insulators a small regulated amount of air is admitted to prevent conductive dust or fume from working back and settling on the insulators.

The cam and shaker rod extending across the middle of the unit was originally designed for the purpose of vigorously shaking the electrodes as it was greatly feared that the removal of precipitate from the electrodes in units of this size might be one of our most serious problems. In actual operation it has been found, however, that the electrodes can easily be shaken by hand from the top entirely free from dust, the whole operation including cutting the unit in and out of the system and the removal and replacement of its covers requiring only about ten minutes, and this having to be repeated every six or eight hours, depending on the dust content of the gases. The precipitated dust and fume as it falls from the electrodes is carried by the conveyor in each unit to a common longitudinal conveyor which in turn discharges into cars carrying it away for treatment and recovery of the values that it contains.

Figs. 7 and 8 are photographs of the main stack taken a few minutes apart with the electric current respectively off and on.

Filtration tests show that this plant under favorable working conditions preciptates between 80 and 90 per cent of the suspended matter in the gas, the average over the whole period of operation to date being somewhat less. Under present operating conditions at the smelter this represents some six to eight tons of precipitate per 24 hours.

The gas treating plant as a whole including flues, fans, motors and electrical apparatus cost up to the time it was first put in operation a little less than $110,000. Although many minor changes have since been made none of the larger or more expensive elements of construction have been altered in any material respect.

The total average power consumption for the precipitation plant at present is in the neighborhood of 120 kilowatts. One man can readily control the whole operation in the rectifier house although as a matter of precaution for a new plant under the high tension here used two have usually been on duty. Two laborers and a foreman are employed on the precipitating units and dust-handling systems, although this can probably be reduced somewhat by automatic shaking devices, since as yet the main efforts at improvement have been directed elsewhere.

The volume of gases to be treated varies considerably with the conditions at the furnaces but at present may fairly be taken as averaging between 200,000 and 300,000 cubic feet per minute, and entering the units at from 100 deg. to 150 deg. C.

Lifting Magnets in Foundries*

Economies Resulting from Their Application in an Industry Which Has Been Slow to Accept Them

By H. F. Stratton, Cleveland, Ohio

An analysis of figures relating to the tonnage and the cost of handling the pig used by the foundries in this country, seems to indicate that the lifting magnet is becoming an economic necessity to foundries producing a large proportion of the total foundry tonnage. There appear to be three huge businesses which can profitably use lifting magnets for the transporting of iron and steel products:

First is the steel industry, with probably 10,000,000 tons annually which can be economically handled by the magnet, and in this industry the magnet found rapid and extensive use, with savings to the steel mills of probably close to $1,000,000 annually. Second, the railroads have discovered that magnets are large money savers in the handling of their scrap material, and probably 100 lifting magnets are at present in use at the scrap docks operated by the various railroads throughout this country. In several cases the economies effected by the use of magnets in handling railroad scrap have proved to be so large and so obvious as to warrant the installation of very complete equipments, consisting of special cranes, several magnets, and a convenient and scientifically arranged collection of bins, shears, etc. A quotation from a paper by F. D. Reed, assistant to vice-president of the Chicago, Rock Island & Pacific, will give a summation of this matter. "Sorting of scrap, the way we handle it here, can be done for 4 to 7 cents per ton; in other words, we can handle scrap in and out with our facilities for 10 to 12 cents per ton, including the sorting. Prior to May, 1909 (at which time our crane and magnet were installed), when all scrap was handled by hand, the cost per ton in and out ranged from 30 to 35 cents per ton, which is about what it is costing any railroad to-day that is handling scrap by hand, or even with very good modern facilities for handling, and to keep it down to this figure the railroad must have good and convenient scrap-dock arrangements and efficient organization."

MAGNETS IN THE FOUNDRY.

The third industry, which would appear to have opportunities to effect savings by the use of magnets, is the foundry. It has been estimated that the foundries of this country melt annually about 6,000,000 tons of pig iron and scrap, and although the writer has no definite knowledge of the relative proportions it would seem reasonable to conclude that of this total about 1,000,000 to 2,000,000 tons is represented by scrap iron and steel.

Of these three-named industries in which the lifting magnet can apparently be used to economic advantage, the foundry has been by far the most reluctant to embrace or even to investigate the economies which are apparently open to it.

* Presented before the American Foundrymen's Association Pittsburgh, May 25, 1911.

An analysis of the costs can be best undertaken from the separate considerations of cost of installation and cost of operation. A magnet thoroughly capable of withstanding hard abuse costs about $1,300 per ton of lifting capacity of pig iron. Standard magnets are constructed in about four different sizes, and although this figure just named does not hold accurately for all sizes, yet it is a fairly close index to the selling price and is sufficiently accurate for purposes of estimate. It may be mentioned at this point that the approximate lifting capacities of these different sizes of magnets in service are, expressed in pounds of pig iron per lift, as follows: 800, 1,350, 1,950, 2,400.

Of course, some kind of a crane is necessary for handling a magnet, and if the foundry already has its yard equipped with either an overhead traveling crane or a locomotive crane, the installation of the lifting magnet becomes a simple and relatively inexpensive matter. If it be applied to an electric overhead traveling crane, it is merely necessary to run leads from the crane to the magnet, and to provide some simple mechanism for taking up the slack in these leads as the magnet is hoisted. If the magnet be applied to a locomotive crane, current can be furnished to the magnet either by suitable plug stations installed at various point in the yard, or an engine taking generator set can be put on the crane, the generator delivering current to the magnet and the engine taking steam from the boiler of the locomotive crane. This latter arrangement, while more expensive in first cost, is preferable in that it provides a flexible unit which is operative at any place which the locomotive crane can reach.

A high-grade four-wheel ten-ton locomotive crane, complete with an engine generator outfit, can be installed at an expense of about $5,500, and such a crane will handle a magnet at a boom radius of about 40 feet, thereby covering a large area, even if the crane runs on only one track. Of course, by the use of parallel spurs, a large area can be conveniently, cheaply and completely served by the locomotive crane. A locomotive crane is of such general use to a foundry that it is only fair to charge here a portion of its cost to the magnet. The locomotive crane can, for instance, be used for loading and unloading heavy castings and machinery, and for shunting freight cars. For about $1,000 extra it can be equipped with a two-line outfit and a bucket for unloading sand and coal. If we consider that $3,000 be a proper proportion of the locomotive crane cost to charge against the magnet, and if a magnet be selected of such size that it will have a lifting capacity of about 1,350 pounds of pig iron, the cost of the magnet installation then becomes about $3,900, or, in round figures, $4,000, installed and ready to operate.

THE OPERATING COST.

The operating cost of a magnet consists of certain charges, including operator's wages, fuel and oil, which will exist only when the magnet is in operation, and depreciation charges on the equipment which will not depart much annually from a fixed amount, whether the tonnage be sufficient to keep the equipment busy practically all the time or only an hour or two a day. It follows, then, that the operating cost, which is the sum of these two charges, will necessarily be lower per ton of material handled if the equipment can be kept in service the majority of the time. Most foundries, however, do not melt sufficient metal daily to require the services of the magnet more than two or three hours per day.

A concrete case will be selected for the double purpose of indicating how similar estimates may be made to cover any particular foundry, and for pointing out a daily tonnage at which the installation of the magnet and crane appears to be an economic necessity. The assumption will be made that a foundry melts 35 tons of metal daily, 300 days in the year. All of this metal must, of course, be handled twice; that is, it must be unloaded from the car to piles and loaded from the piles to some kind of a wagon on which it is carried to the cupola platform. For a foundry of this capacity the following figures pertain:

Charges per Hour.

Operator's wages	$0.30
Fuel (at $3 per ton and using ½ ton per 10 hours)	.15
Oil, etc.	.03
Total	$0.48

A crane and a magnet of the size referred to before will conservatively handle 35 tons per hour, which will make a cost of 1.4c per ton. The annual depreciation on the $4,000 equipment at 12 per cent would be $480, as 35 tons handled twice per day for 300 days represents 21,000 tons handled annually, the depreciation cost on this tonning basis is 2.3 per ton. This brings the total cost of handling, including wages, fuel, oil and depreciation, up to 3.7c per ton. The writer is told by a gentleman well versed in foundry practice that 10c per ton is a fair figure to assume for the cost of loading or unloading pig by hand, and on this basis the saving would be $1,323 annually, or 33 per cent on an investment of $4,000.

MAGNETS IN THE LARGE FOUNDRY.

If the case of a larger foundry be selected, melting, say 100 tons per day for 300 days per year, and assuming in this case that metal is handled more cheaply at, say 9c per ton, by hand labor, the annual saving effected by the use of the magnet is $4,080, or over 100 per cent on the investment. It may be mentioned in

the case of the smaller foundry that the time the magnet is in use daily would be about two hours, and in the case of the larger foundry, with the magnet selected, about six hours daily would be required. In this latter instance it would doubtless be more economical to install a magnet having a lifting capacity of about 1,950 pounds, instead of 1,350 pounds, which was the basis on which the estimates were made.

With these figures fresh in mind, attention is directed to this conclusion: A foundry melting 35 tons of metal daily can install both a crane and a magnet, and expect a return upon the investment, after allowing all charges, of more than 30 per cent. If it happens that a foundry is already equipped with either an electric or a locomotive crane, a magnet can then be installed on a very profitable basis when the tonnage to be handled is considerably less. For instance, if an assumption be made that a foundry melts 20 tons daily, and that a magnet be installed on a hoisting crane the cost of the magnet being about $900, then the cost of handling, per ton, including wages, fuel, etc., and depreciation on the magnet, is about 2.3c, which would represent a saving in this foundry of about $924 each year, or more than 100 per cent on the investment.

Handling scrap, in general, will be more expensive than handling pig iron, whether it be done by hand or by magnet, but the advantage in favor of the magnet is more marked in the case of scrap than in the case of pig. As before stated, the railroads have carefully investigated the comparative cost of handling scrap and large castings by means of magnets and by hand labor, and the following information is therefore submitted as being pertinent to the question of scrap handling in foundry yards. N. A. Mears, of the Lake Shore & Michigan Southern, gives the following comparative figures:

	Cost per Ton.
Loading locomotive tires by hand	$0.17
Loading locomotive tires by crane with chains	.08
Loading locomotive tires by crane with magnet	.04
Loading heavy castings by crane with chains	.20
Loading heavy castings by crane with magnet	.03
Loading heavy castings by hand, almost impossible.	

Another gentleman identified with the railroads states that it costs, for an average of 100 cars, $7 per car to unload scrap by hand, and $2.83 per car to unload the same character of scrap by crane and a magnet. Mr. Reed, of the Chicago, Rock Island & Pacific, says he can unload unsorted scrap with a magnet at 2c to 5c per ton, and sorted scrap at ½ to 1½c per ton. When this work was done by hand labor the expense was about three times as much.

Exclusive of the economies already cited, incidental advantages, somewhat in the order of their importance, may be mentioned as follows:

1. The elimination of labor trouble, this being particularly true where common laborers are apt to be very unreliable, as in the South; or where the demand for labor for harvesting the crops is extraordinary at certain times of the year, as in the West.

2. The ability of a lifting magnet to handle a drop ball for the breaking of castings too large to charge into the cupola. For this application the magnet not only serves to lift and release accurately the ball, but also to pick up and transport the broken pieces of the casting. For this particular work, not only is the matter of economy to be considered, but also the question of increased safety to the operator.

3. The ability of a magnet to unload castings too heavy to handle by hand, and often of such shape as to be very inconveniently handled even by a crane with chains.

4. The ability to stock pig and scrap in piles higher than would be possible were hand labor employed, and thereby make more efficient use of the available space in the foundry yard.

5. The ability to unload cars more quickly, and thereby save demurrage.

6. The recovery of small pieces of iron in the bottom of freight cars, which can be magnetically swept up, but which would be neglected if the cars were unloaded by hand. This figure is considerable in the aggregate, and has been as high as 700 pounds a car.

7. The convenient recovery of nails and iron shot in foundry sand. This is accomplished by slowly passing the magnet above the sand and as close to the sand as possible, and as it passes over successive portions of the ground the small iron and steel particles, mechanically associated with the sand, will break through their confinement and leap to the magnet bottom, where they will be held until the magnet is de-energized.

8. Independence of weather is particularly noticeable in the South, where the negro is temperamentally opposed to cold weather, and where difficulty is sometimes encountered in getting the common laborer to work out of doors during cold and inclement weather. The magnet lifts more on a cold day than on a hot one, and will lift pig iron when covered by snow.

THE ELEMENT OF DANGER.

The question of safety is often raised, and during the time when the magnet was being commercially introduced its use was frequently combated on the score that it was dangerous to workmen. Of course, it cannot be denied that if a man is standing under a magnet that is carrying a load, and the circuit is interrupted, something is going to happen to that man. The writer maintains, however, that it is safer to use a magnet for the transportation of material than it is to use chains, and for several reasons: First, the magnet is inherently a labor-saving device, and when it is used the number of laborers in its vicinity is reduced, and frequently the magnet entirely displaces ground labor. Second, a laborer always looks upon a magnet with a high degree of suspicion, since there is nothing tangible to hold up the load, and he avoids getting under a load supported by a magnet more than he would under a load supported by chains; in other words, he uses more caution. Third, the accidental opening of the magnet circuit probably does not occur as often as the breakage of chains supporting a load.

A Simple Electroplating Apparatus

Some Hints for the Amateur

One of the most interesting properties of the electric current is its power to decompose liquids. If, for example, the ends of two copper wires, connected with the poles of a galvanic battery of several cells, are immersed in an acid solution of copper sulphate (blue vitriol), the immersed portion of the wire connected with the zinc pole of the battery gradually increases in thickness, owing to the deposition of metallic copper derived from the decomposition of the copper sulphate, while the end of the other wire becomes thinner by combining with the liberated sulphuric acid and thus replacing in the solution the copper which is deposited on the first wire.

This phenomenon, which is called electrolysis, forms the basis of the important industries of electroplating and galvanoplating, in which objects are coated with gold, silver and other metals, and copies of small objects are made in various metals.

The processes of electroplating with gold, silver and nickel are difficult and require the use of cyanides, which are very poisonous, and working with gold and silver is expensive. Hence the amateur had better confine his attention to copper, which can be deposited easily, cheaply and safely.

The electroplating bath is made by dissolving three parts by weight of copper sulphate in ten parts of warm water, allowing the solution to cool, and then filtering it and adding one part of weight of sulphuric acid, gradually and while stirring, as the addition of the acid generates a good deal of heat.

Pour the solution into a glass or earthen vessel and lay over the top two stout copper or brass wires, or thin rods, passing through corks which, being pressed against the sides of the vessel, hold the rods in place, and parallel to each other (Figs. 1 and 2). Each of these rods should be connected, at one end, with one of the wires leading to the battery. The connection may be made by means of screw clamps or by winding the small wire very tightly round the rod, after both have been scraped to brightness. Or two short pieces of the small wire may be soldered to the rods, as shown in the illustrations.

Now bend one end of a short piece of large copper wire into a hook, solder or clamp the other end to a piece of sheet copper and hook the wire over one of the horizontal rods. The sheet copper is used to replace the copper which will be deposited from the solution. Over the other rod hook a similar wire which has a second hook at its lower end for the purpose of supporting the object to be plated.

Sufficient current for an experiment in electroplating can be obtained from a dry battery, such as is used for pocket electric lamps. The longer of the strips of brass which protrude from the battery is the zinc pole and should be connected with the rod

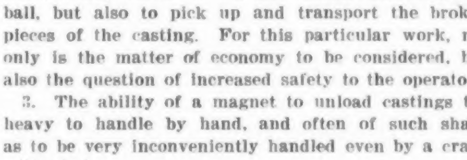


Fig. 1.—Supporting Rods and Corks.

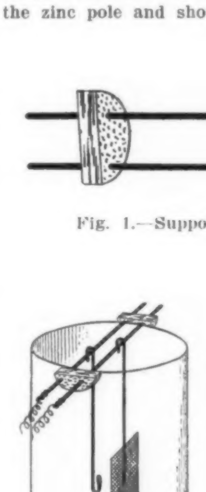


Fig. 2.—The Electroplating Cell.

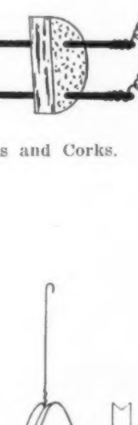


Fig. 3.—The Plaster Mold and Its Support.

which supports the object to be plated. If the battery has no binding posts or clamps, connecting wires may be soldered to the brass strips. The wires which connect the battery with the electroplating vessel may be spliced at any point by carefully scraping the ends and twisting them very tightly together, but the splices should be as few as possible. The wires should be neither very long nor very fine and they should be insulated or kept apart from each other.

Any small object of white metal which has been thoroughly cleaned with soap and water, is placed on the lower hook of the object-carrier and secured by pinching the hook. The object-carrier is then hooked over its rod so that the object is immersed in the electroplating bath. The object will soon be entirely covered with a thin plating of copper.

Medals, coins and similar articles may be copied by the following process. The article is cleaned with soap and warm water, dried and wiped with a cloth which has been dipped in olive oil. The edge of the medal is then bound with a strip of gummed paper, about one-half inch wide, to form a shallow cup, resembling a pill-box, the bottom of which is formed by the medal. This box is filled with a thick paste of plaster of Paris and water, which quickly "sets" or solidifies, but is left undisturbed for half an hour. The paper is then removed and the plaster cast, or mold, is easily separated from the oiled medal. The mold, which should show every detail of the medal, is allowed to dry over night. A groove is then made round its edge with a file for the reception of a copper wire by means of which it can be attached to the object-carrier (Fig. 3). The cast is varnished to saturation with a solution of 1 part by weight of shellac in 10 parts of alcohol, and its face and edge, as far back as the wire, are thoroughly coated with pulverized graphite, which is applied with a soft brush. As the graphite is employed to furnish a conducting surface, it must cover, without obliterating, every detail of the design, and establish a good connection with the wire. When the superfluous powder has been shaken off the surface should show a uniform gray luster.

The mold is then suspended in the electroplating bath, facing the sheet of copper, and the battery is connected. A new dry battery may be employed but it is better to use two or three of the sal ammoniac cells which are employed to operate electric bells. It will occupy from 12 to 36 hours, according to the strength of the battery, to form a deposit of sufficient thickness. Any air bubbles which appear must be dislodged by gently shaking the mold. When the deposit is thick enough, the mold is taken from the bath, wiped dry and separated from the copper with the aid of a knife. The upturned edge of the copper is then cut off with shears and the face is washed with warm water and polished with a wire brush.




A New Portrait of Constantine the Great

A Splendidly Preserved Record of a Prominent Historical Figure

By Alfred Emerson, Chicago Art Institute

The writer is indebted to the courtesy of the Royal Museum of Belgrade, and to the kind offices of the Serbian Legation at London, for several views of a fine bronze head of Emperor Constantine. A native scholar has had the good fortune to discover this treasure at Nisch. That ancient Slavonic stronghold is the Serbian Moscow. It occupies the site of the Roman city of Naissus. It will be recalled that Constantine's father was a plain colonial gentleman of the Illyrian hinterland, and that Constantine himself was born at Naissus. Nisch deeply regrets its forfeiture to the Danubian capital of a relic so intimately related to its own history.

There is little to say of this antique head that our pictures of it do not proclaim. Constantine's own gold, silver and bronze coins are the only safe touchstone to control the resemblance. The Belgrade bronze tallies well with the numismatic profiles. But even this test is fallible. The die-cutters varied their lines, and the Christian emperor had four sons and several nephews who resembled him. Compare the photographs of Emperor Nicholas and King George of England for the physiognomic effect of first cousinhood.

Thus it comes about that four marble statues and one giant marble bust, supposed to represent Constantine at Rome, are questioned likenesses of him. A bust which finishes the series of the Cæsars at the Louvre Museum, one bearing the label "Constantino Imperatore" at Florence, and a fifth Roman head are true portraits of fourth century emperors, but they do not represent Constantine I. The new head at Belgrade is upon the whole perhaps the most surely authentic and contemporary likeness of Emperor Constantine the great which has been found preserved.

Roman sculpture was at a low ebb in the Constantinian age. The Arch of Constantine at Rome, with its superbly carved panels and medallions, which the Senate consecrated to the conqueror of Maxentius in 316 or thereabouts, seems to confute this sweeping judgment. But we know that the Senate despoiled the arch of an earlier emperor to embellish the newer one. The friezes that were chiselled expressly for this monument are poor enough. And so, I may now add, are the Constantinian relief sculptures on the pedestal of the Hippodrome obelisk at Constantinople.

But it is unhistoric to judge either those marbles or the Belgrade head by a Beaux-Arts standard. And a new artistic impulse did go hand in hand with Diocletian's and Constantine's great rehabilitation of the Roman currency on the sound basis of metallic values. Constantine's money recovered something of the Augustan elegance, and there was some revival in the major arts. The Belgrade bronze is in short less barbaric, and more sympathetic in its crudities, than the bronze statue of his predecessor Trebonian in our Metropolitan Museum. Fourth century Roman sculptors exulted in cavernous orbital arches, in big, staring eyes, sheltered by braided eyebrows and flanked by vast listening ears. These exaggerated accents match the inflated Greek and Latin rhetoric of that period. The general shape of his head is still very Roman, however, and the brush and trim of its straight Italian hair is fairly Augustan once more. Trebonian's hair was clipped.

A heavy, linked crown, the copy of a gold one, encircles the emperor's skull. A large medallion surmounts his forehead. In life this was a stately cameo. So much for the Christian emperor's majesty. But the mystic glory, or the character of a religious visionary, is conspicuously absent. The vital features of the statue portray a Constantine of the camp, a victorious captain revisiting his native Serbian mountains in the full flush of his manhood, fresh from his conquest of Italy. This was the general whom his legionaries feared for his severity and adored for his largesses. What did the garrison of Naissus know of the tricky politician whose steamroller commanded episcopal majorities at the Council of Nicaea a dozen years later? But it nursed a warm sentiment for the ruler who had ordered the army to observe the most holy day of the sun, as a weekly holiday.

Constantine's Christian subjects freely forgave or conveniently forgot his treacherous political murders of his wife's father Maximian, or his sister's husband, the exiled pagan emperor Licinius at Salonica, and his own son Crispus. They owed him no less for the edicts of toleration he promulgated in their behalf. We ourselves are compelled to measure Constantine's merits by his success. This man established a tottering state and throne, a new imperial capital, the free coinage system, Sunday observance, the Papacy, and the Christian church itself, amid crucial difficulties. And all these institutions survive him yet, even to the throne of Byzantium. They make him one of us, almost an Anglo-Saxon. His father's British legions proclaimed Constantine emperor at York. New York has ground to be jealous, like Nisch, of Belgrade's prize.

Earthquakes and Lumious Phenomena*

By John Milne.

In Vol. XIV., Nos. 6, 7, and 8, of the *Bollettino della Società Sismologica Italiana*, we find a very long paper by Dr. Ignazio Galli on the collection and classification of luminous phenomena observed at the time of earthquakes. After an introduction, he considers that which might be excluded and the difficulties first met with in the formation of a catalogue of the phenomena he discusses. The illustrations which he gives of luminosities and other strange phenomena which have appeared at or about the time of earthquakes are 148 in number. The date of the first is 89 B. C., and the last March 30, 1910. These descriptions occupy 184 pages. The various luminosities are classified under more than twelve heads, and to these are added the number of times that earthquakes have been associated with vapors, smoke, and odors of sulphur or bitumen.

Seismologists have known for years past that certain earthquakes are said to have been accompanied by appearances of the Aurora Borealis, glimmering lights in the sky, fire-balls, *ignis fatui*, lightnings, corruscations and emanations from the soil, but this is the first time so large a collection of these phenomena have been brought together for their consideration.

When a resident in Japan the present writer made many experiments extending over some years on electrical and magnetic phenomena associated with seismic disturbances. He also collected material from all parts of the world which bore upon these associations. One conclusion arrived at is that it is an undoubted fact that at the time of certain large earthquakes, as, for example, the one which in 1906 destroyed Valparaiso, curious lights which, in this instance, were compared to those of chain lightning, have been seen playing across the hills in the epicentral region. Observations of this nature led the writer to make experiments at Shide, in the Isle of Wight, and at the King Edward VII. mine at Camborne, in Cornwall. The object was to determine whether there was or was not at the time of a large earthquake a practically instantaneous transmission of energy to distant regions other than that recorded by seismographs. It was observed, and still is observed, by many persons that the face of a very large chalk-pit at Shide exhibits, after dull damp days, a flaring luminosity. In a chamber at the end of a tunnel in this pit, a cylinder carrying photographic paper was installed. This cylinder was inclosed in a box, one end of which was a metal plate containing three holes. The plate touched a flat chalk surface. The cylinder took one week to turn; therefore parts of the paper before the holes were very slowly exposed to a chalk surface about 3/16ths of an inch distant. On certain weeks the results were nil. Other weeks, after the development of the paper, there were three dark bands corresponding to the position of the holes, suggesting that the chalk had acted like an extremely feeble light.

The conclusion arrived at was that the photographic effects were in no way connected with radioactivity, but they were probably electrical. The effects obtained in the granite of Cornwall were very marked and, like those observed in the Isle of Wight, varied in their intensity. As to the possibility of these effects being due to micro-organisms, a number of investigations were made, but there were no indications that organisms obtained from the chalk surfaces were connected with luminosity.

The 148 detailed descriptions which he has collected are used as subject-matter for twenty-six analyses. For example, did lightnings, thunderstorms, meteors, beams of light, luminous clouds, hot vapors, and other appearances precede, accompany, or were they noted after an earthquake? Dr. Galli says that sixteen of these analyses are nothing but the analytical *résumé* of the various phenomena which have been observed, and they therefore possess a real value which cannot be sensibly altered by any report that is ill-founded or untrustworthy. The remaining ten are provisional conjectures which await the judgment of physicists and seismologists. They will be confirmed or contradicted by future observations. If they fall, either partly or entirely, they will at least have the merit of having put the question as to certain probable causes of luminous phenomena connected with earthquakes. At the same time, as one heartily wishes, they may suggest hypotheses which are better, broader, and more synthetic than those the writer of the paper has brought forward.

* Originally published in *Nature*.

Useful Products from Willow Bark

Recovering Values From the Waste of Basket Making

COMMERCIAL willow bark is obtained as a by-product in the cultivation of willows to be used for basket making. The barks of most willows contain sufficient tannin to make them valuable for tanning purposes. In Europe, and particularly in Norway, Sweden, Denmark, Holland, Belgium, France, and parts of Russia, the highest grade of tannin is obtained from this source. Russia alone consumes annually no less than 20,000,000 pounds of willow bark. Many special kinds of leather, such as the Muscovy (Russia) leather and Danish glove leather, are prepared exclusively with tannin from willow bark, which imparts a characteristic odor, a light color, and considerable pliability. In Germany, Austria, and France the use of this bark is increasing steadily. Yet up to the present time willow bark has had no market value in the United States. There is little doubt, however, that it will be widely used here for tanning as soon as its value is generally known. As soon as the bark can be obtained in sufficiently large quantities by tanning extract concerns, willow growers will have no difficulty in realizing an additional revenue from the sale of this product. It is estimated that during the past year at least 1,000 tons of willow bark have been wasted in this country—material which might have been turned to economic use.

About a half ton of dry bark may be obtained from an acre of basket willows, and that of the best varieties sells in Europe as high as $30 per ton. In France the bark of all cultivated varieties is used for fodder and bedding for cattle and sheep. For this purpose it has a market value of $15 per ton. It is also utilized in the manufacture of door mats which outlast those made from straw or rush. The inner portion of the bark has been used recently in weaving a coarse fabric from which sacks are made. In certain parts of Germany the green bark is also employed in making beer, which is said to be exceedingly bitter.

A Pile of Willow Bark from Which Tannin Is Obtained.

Not all willow barks have the same value for tanning. The bark of large one or two-year-old rods is the best for the production of tannin extracts, while the corky bark of older trees is seldom used, because its tannin yields are small. In Russia the bark of sand willow (*Salix arenaria*, L.) and of fever willow (*Salix fragilis x alba*, Wimmer) are used most commonly. In central Europe the bark of several willows yields commercial tannin. Among the most important of these are the common white osier (*Salix viminalis*, L.), the almond willow (*Salix amygdalina*, L.), and the Caspian willow (*Salix pulchra*, Wimmer et Krause).

From a chemical standpoint the various willows may be divided into two groups; those with a large amount of salicin and those with a large amount of tannin. To the salicin group belong, in particular, the purple willows (*Salix purpurea*, L. and *S. viminalis x purpurea*, Wimmer), which have a tannin content of from 8 to 10 per cent. The tannin willows yield from 13 to 16 per cent. The Russian sand willow belongs to this group. The almond willow and related varieties contain from 10 to 16 per cent of tannin. Samples of bark from the willows grown principally in this country were analyzed by the Bureau of Chemistry of the Department of Agriculture in order to determine the percentage of tannin available in the bark of each variety. The amounts are as follows, by varieties:

Purple willow (*Salix purpurea*, L.), 8.75 per cent.

Lemley willow (*Salix pruinosa acutifolia*), 6.98 per cent.

Patent Lemley willow (*Salix pruinosa acutifolia*, var.), 6.41 per cent.

American green willow (*Salix amygdalina*), 11.38 per cent.

The bark of purple willow is largely used for the production of salicin. In preparing either tannin or salicin bark for market, it is cut into pieces ten or twelve inches long, dried thoroughly, and stored in a dry place, because bark which is allowed to become wet after it is dried loses its value as a source for either of these two products.

A reddish-brown coloring matter known as Bismark brown is extracted from the bark of Lemley and related varieties. This color is used in staining leather and certain tissue for microscopic examination.

Testing Cereals for Their Resistance to Disease

A Mechanical Gauge for Measuring Their Vitality

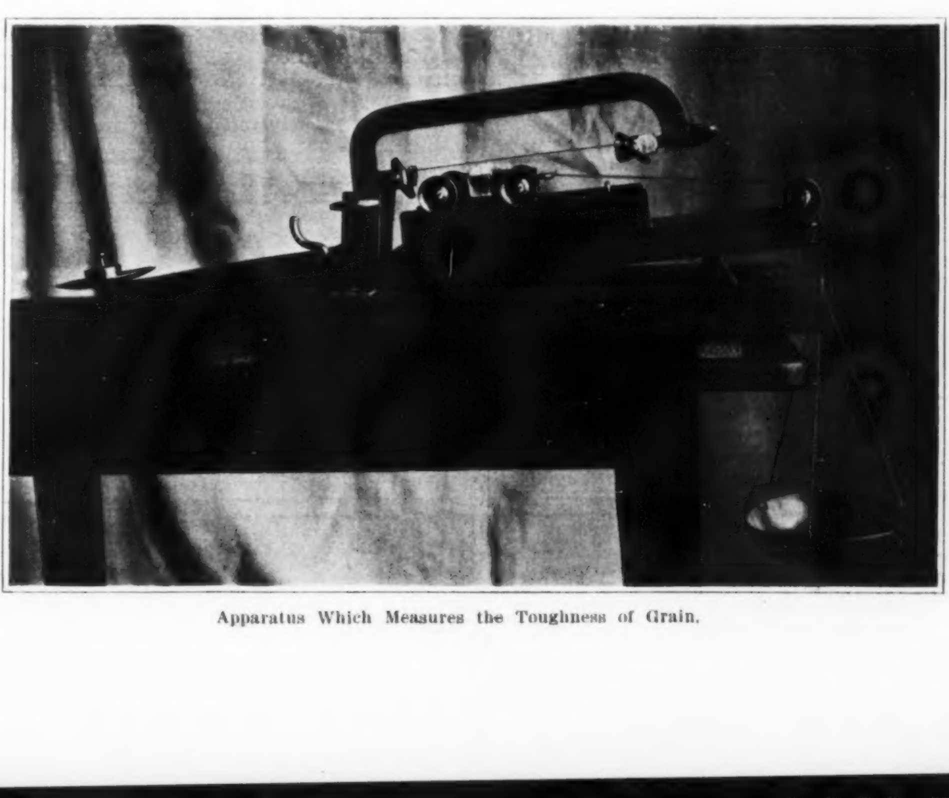
By the Berlin Correspondent of the Scientific American

IT is well known that different brands of cereal plants offer varying resistance to the attack of diseases, blight, mildew and other pests. This fact is brought out with particular force at the time of agricultural epidemics, such as the invasion of wheat by a certain fly which last year wrought immense damage throughout practically all European countries. While some varieties of wheat were completely destroyed, others, under precisely similar conditions, were harmed but little or not at all.

This remarkable circumstance induced Dr. F. R. Stranak, professor at the Bohemian Technical High School of Prague, to undertake the investigation of the highly important problem presented, and to ascertain the cause of this variable susceptibility of the different brands of grain. As a result of his efforts, he has proved that the anatomical structure of a plant is the chief determining factor. The character of the more or less lignified cell layers below the epidermis and other membranes determine not only the strength and hardness of the plant but also its power of resisting various harmful external influences. An extended series of microscopical examinations show all healthy plants to possess a much more substantial cell tissue than those attacked by the pests. Thus the weakness of the plant, so far from being the result of the pest itself, was found to be a preexisting disposition.

While these results, the fruit of painstaking microscopical research, evidently sufficed to throw light on the trouble, Dr. Stranak sought to confirm them by an even more direct demonstration, namely, by the mechanical determination of the hardness of the parts in question by means of a specially constructed apparatus. The results thus obtained are so uniformly concordant, that the apparatus can be used with great confidence as a simple means for ascertaining the susceptibility of different kinds of cereals to the diseases to which they are subject.

In this apparatus the hardness of the plant portion considered is determined by means of mechanical impact which is devised to imitate the mode of attack of the pest. The apparatus designed by Prof. Stranak is shown in our accompanying illustration. It comprises a saw, so designed that its action upon the epidermis of the plant resembles closely the attack by the mandibles of the insect. This saw is allowed



Apparatus Which Measures the Toughness of Grain.

to descend with a predetermined force on the surface of the plant portion (blade of cereals, etc.) the hardness of which is to be tested. The plant offers to the saw a resistance in proportion to the hardness of its outer integument. The force required to overcome this resistance is measured by means of a weight. Thus the apparatus consists of two essential parts, the saw stretched upon one arm of a lever, and a miniature truck carrying the plant under investigation. The saw is of the finest English make with teeth 0.1 millimeter deep and 0.3 millimeters apart. The pressure of the saw upon the plant is adjusted by varying the weight placed upon the lower arm of the lever. The truck under the saw moves on inclined rails and is connected by means of a cord to a scale plan which receives a suitable weight (small shot). When the weight placed in the plan is sufficient to overcome the resistance of the plant against the saw, the little truck travels along the inclined track against the teeth of the saw; the weight which is just capable of producing this effect is noted and serves as a measure of the hardness of the plant portion.

The figures thus obtained are found to be in full agreement, not only with the microscopic indications regarding the anatomical structure of the plant, but also with the degree of susceptibility to or immunity against, the invasion by pests. The apparatus thus affords a very excellent means of selecting the most resistant from among a choice of brands of cereal plants.

Problems in Telephone Traffic Engineering.—II*

Some of the Difficulties That Arise in Serving a Heterogeneous Territory

By F. P. Valentine

Concluded from Supplement No. 1864 page 199

PRODUCTION EFFICIENCY OF TRUNK AND TOLL CIRCUITS.

The production efficiency of trunk and toll circuits is affected by the quality of service which it is desired to produce, by the efficiency of operating labor, and by the efficiency of operating methods, and to a certain degree, by the efficiency of central office equipment. It is also affected by the volume of traffic to be handled and the contract conditions under which the service is sold.

Analysis of this subject has demonstrated that while operating and equipment costs vary directly with the number of unit calls, circuit costs vary indirectly with the number of calls, due to the varying efficiency of circuits in groups of different sizes, and more or less directly with the length of haul under a given amount of traffic, except so far as qualified by variation in type of plant necessary to meet transmission requirements.

The production capacity of a circuit under any method of operation, is determined by the average circuit holding time per call and the number of calls to be handled over the particular group of circuits in a given time.

For proper consideration of the subject of circuits, distinction will be made between trunk and toll circuits. Trunk circuits may be considered as local circuits connecting offices covering an area of too great telephonic density to be served economically from one central office, and in which case local service, so called, is sold covering intercommunication between the several central offices. Toll circuits will be defined as circuits between offices more distant from one another and between which the service is sold on a message basis, the charge being graded according to duration of connection and distance involved.

Toll circuits, however, must be considered in two classes, one embracing the "short-haul" or suburban toll traffic, and the other the "long-haul" or "long distance" traffic. The former class may be considered on the same basis as trunk circuits, so far as concerns production efficiency and engineering.

The trunk circuits and "short-haul" toll circuits are provided for the purpose of handling calls on a local basis; that is, the telephone subscriber passes the desired number to his operator and remains at the telephone until the connection is completed or a report returned to him of inability to complete. This feature of the trunk and "short-haul" toll operation necessitates providing a sufficient number of circuits between two offices to handle the traffic offered during the busiest period so that there is always a circuit available when a call is to be handled.

The "long-haul" circuits are for economical reasons provided on a less liberal basis, which contemplates that the calls will not be handled while the subscriber remains at his telephone.

A comprehensive series of studies on the subject of circuit use has resulted in development of methods by the use of which all the elements entering into circuit use can be given proper consideration, and the most efficient operating methods applied to existing conditions.

In figuring circuit loads, as a matter of convenience, it is usual to consider the load for a given group of circuits, rather than for a single circuit. As the circuit holding time is made up the time of conversation plus the use of the line for operating purposes, the total holding time for a call will differ according to the operating method used; for example, the local or "short-haul" toll requires less holding time than that handled on the "long-haul" basis. Also the efficiency of the individual circuits increases as the size of the group increases. These various factors have been studied and reduced to known quantities.

Having ascertained the production capacity of circuits under various conditions of volume of traffic and methods of operation, it is possible to set the proper standards to apply, and with which to check actual results, so far as concerns individual groups of circuits. The study of this matter, however, has developed the fact that in order to properly engineer the circuit plant for handling the traffic between several hundred offices, the subject is far more complex than would appear at first sight. In considering the circuit efficiency between two offices, as these same circuits may carry in addition the traffic to other points, the plant must be considered as a whole. The comprehensive study which has been referred to, has developed methods by which the circuit plant can be intelligently laid out with predetermined results. The problem in laying out a circuit plant is to furnish the proper standard of service as to accuracy, speed and transmission, with a minimum investment in line plant. It is obvious when one considers the variety of types and grades of trunks and toll circuits that this is no small matter.

The production efficiency of a trunk and toll circuit plant has usually been figured either by computing the number of calls handled per circuit or the earnings per circuit mile. Neither of these methods, however, gives the true measure of circuit production efficiency, inasmuch as for economical reasons it is often necessary to switch long-haul calls through one or more intermediate offices, and on account of the varying size of the circuit groups and the consequent variation in the capacity of individual circuits, the real production efficiency of the circuits cannot thus readily be determined. On the other hand, comparison of the earnings per circuit mil would be very misleading if any change in rates had been made between the periods under consideration.

A far more logical means of measuring the production efficiency of a trunk and toll circuit plant is afforded by computing the number of message miles produced per circuit mile. By computing the former on a basis of air line measurements between points of connection and the latter on the basis of actual circuit route mileage, a means is afforded of checking the efficiency of circuit plant layout, not only from the standpoint of efficiency of labor and methods, but also from the standpoint of economical plant layout.

In the foregoing sections there have been discussed in a somewhat incomplete way, some of the principal factors entering into the consideration of traffic engineering problems. Each of these factors has involved most comprehensive study, a discussion of which would involve a paper of considerable length. There is a close relation and inter-dependence between them all. The quality of service is affected by all the other factors, and itself has to be considered in connection with each one. To illustrate the complexity of the problems, and to indicate the possibilities in construction application of the principles deduced from their comprehensive analysis, it is proposed to discuss the concrete application of some of the results of the engineering studies of the last few years in the development of a toll operating system and plant.

From the standpoint of the telephone user, the ideal toll service would afford connection with the most distant point with substantially the same celerity as obtains in case of a local connection. The development of a toll operating system should be toward this ideal as far as economically consistent.

The handling of toll business at special toll boards, or at separate positions on the local board, developed for two reasons. While the operating and equipment charges, under a given toll operating method, are fairly constant, the circuit charges increase in weight with the length of haul. In view of the large investment involved in long toll circuits, it was deemed necessary for economical reasons, to make each circuit handle all the messages possible, and it was generally customary to handle such calls on the basis of arranging to have both parties ready to talk before the circuits were put up for the actual conversation. From the nature of operating procedure involved in handling traffic on such a basis, it was obviously necessary to remove the handling of this type of call, involving extra labor, from the *A* or subscriber's operator, as it would, if handled by the latter, prevent the smooth, quick answering and handling of local connections. Further, on account of the extra labor involved, the productive efficiency of the operator and switchboard were very substantially reduced. It was, therefore, necessary to specialize and segregate this business. Where the local board was of fair size or an expensive multiple board, it was economical to set up an entirely separate board carrying only the toll circuits, the connection with local subscribers being made through the medium of switching circuits between the boards.

For a clear understanding of the explanation to follow, it will be well to briefly describe some of the most generally used methods of toll operation.

The operating methods employed in handling the toll traffic may be divided into two classes, "short-haul" and "long-haul." In the case of the "short-haul" method the subscriber, who must pass his call by number, waits at his telephone until the called station answers, as he would on a local call. In the "long-haul" method, however, the subscriber, having given his call to a recording operator—specifying a particular party if he so desires—hangs up his receiver and waits for the toll operator to call him.

Calls of the latter class are further subdivided according to the operating method employed, namely, the two-ticket method, single ticket ring down method, and single ticket call circuit method.

Under the two-ticket method of toll operating the subscriber signals his local operator, asks for and is switched to the toll recording operator, to whom he passes information sufficient to insure the completion of his call, hangs up his receiver and waits to be called. The recording operator having written the necessary information on the toll ticket, forwards it to the line operator, who secures a toll line to the called office, rings, and when the inward operator answers, passes the details of the call, which are again recorded by the inward operator. The latter operator assumes the responsibility of obtaining the particular party; having done this she notifies the outward operator, who thereupon rings the calling subscriber. Both operators supervise and time the call, entering on the tickets the length of conversation and both are responsible for the prompt release of the toll circuits after conversation ends.

The single ticket ring down method of handling a toll call is the same as the two-ticket as far as the recording of the call is concerned and up to the time of passing the call by the outward operator, who does not pass the details of the call, but simply the called number to the inward operator, who, without making a second ticket, rings the desired number. The outward operator announces the call to the called subscriber, and assumes sole responsibility of timing and supervising the call, and of releasing the circuits after conversation ends.

The operation of the single ticket call circuit method is similar to the single ticket ring down. It is faster in that the outward operator secures the called station over call circuit trunks to a *B* switching operator in the distant office, thereby eliminating the services of an inward toll line operator.

The "short-haul" methods are subdivided into the "toll board" and the "*A-B*" method.

Under the former, the *A* or local operator receiving from the subscriber the number desired, passes the calling and called numbers directly to a toll line operator, thus eliminating the recording operator as a separate operator. The toll line operator records the call and after ordering the calling subscriber's line to be held on a trunk to the local switching operator, secures the called number as under the single ticket methods of operating.

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Under the *A-B* method the toll operator is eliminated, the *A* operator recording the toll ticket and completing the call over a trunk to the distant office. She alone is responsible for supervising and timing the call. This *A-B* method may be on either a ring down or call circuit basis as may be most economical.

There are further refinements of these methods, in the way of "tandem" toll operation, etc., which are purposely omitted from this discussion, as it is impossible to go too much into detail, and the typical methods shown will serve to illustrate the processes described in the following:

Considering first the efficiency of labor involved in handling a toll call, Fig. 2 shows the relative requirements of operating labor under each of the above described methods.

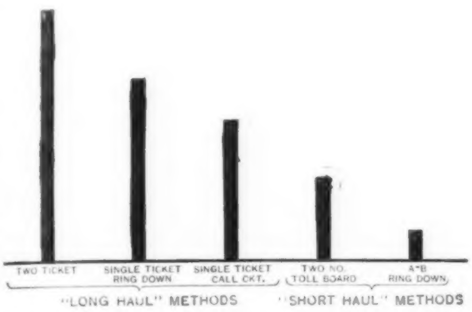

Fig. 2.—Relative amount of operating labor required to handle a toll call by the various operating methods.

Considering the production efficiency of central office equipment under the same operating methods, Fig. 3 shows the comparison of relative requirements in the way of switchboards and accessory equipment for the operation under each method.

It will be noted that in case of both the central office labor and central office equipment, the "short-haul" methods are relatively more economical than the "long-haul" methods. Bearing in mind that the toll circuit efficiency is affected by many variables, as has been explained, chiefly volume of traffic, length of haul and circuit holding time, it is necessary to consider this factor in connection with the efficiency of labor and equipment. Obviously, to handle traffic on a "short-haul" basis, requires more circuits than to handle the same traffic on the "long-haul" basis. It is necessary, therefore, to ascertain under what conditions it will be economical to apply the more efficient operating methods, considering all factors involved.

The process by which the principles deduced from engineering studies are applied to a territory involving a large number of offices of varying sizes and volumes of traffic, may be best illustrated by taking a hypothetical case, as shown in Fig. 4.

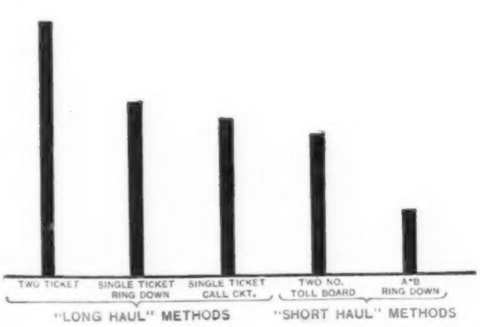

Fig. 3.—Relative amount of switchboard required to handle a toll call by the various operating methods.

A and *B* are fair sized offices 30 miles apart. *C*, *D* and *E* are offices separated from *B* by 5, 8 and 20 miles, respectively. *F* is between *A* and *B* and slightly off the direct line being 24 miles from *A* and 8 miles from *B*. The traffic between these offices is indicated in the table adjoining Plan 1. This traffic is shown in the number of calls per day rather than per busy hour, for the sake of clearness. In the actual engineering, the busy hour loads are used.

It will be noted in Plan 1, Fig. 4, that the circuits are laid out in a way generally typical in past practice, the tendency being to furnish direct circuits between points having a fair volume of daily traffic. Under this Plan 1, there are toll positions or toll boards at each of the offices. It will be noted that there are 14 circuits between *A* and *B* divided into several groups, also that there is a fair amount of traffic between *B* and *C* and *B* and *D*, with slightly less between *B* and *D*.

Under Plan 2, the traffic between *B* and *C*, *B* and *D* and *B* and *F*, has been taken from the toll position or toll board and is handled on the local boards on the "short-haul" *A-B* basis. *C*, *D*, *E* and *F* continue to handle their toll traffic with *A* on toll positions and over direct circuits. At the right of Fig. 4 are shown the comparative requirements under the two plans. It will be noted that, in order to handle the traffic between *B* and *C*, *B* and *D* and *B* and *F* on a local basis through the local board, additional circuits had to be provided to place this traffic on a "short-haul" basis. This increased the circuit requirements, but made a material reduction in the operating requirements as shown, while the equipment requirements increased slightly owing to the transfer of the toll business to the more expensive local board. The composite result, however, is a substantial gain in economy.

Having placed the traffic between *B* and *C*, *B* and *E*, *B* and *D* and *B* and *F* on a "short-haul" operating basis, the way is open for still further modification. Plan 3, Fig. 4, shows the next step, which is the centering of all toll operation for *B*, *C*, *D*, *E* and *F* on the toll board at *B*. Placing the traffic between these tributary offices and *B* on a "short-haul" basis will permit of recording at *B* all toll calls from these points to *A*, practically without loss in time. The operators on the toll board at *B* can order up connections through toll switching operators at the tributary offices with the same efficiency and speed as with subscribers at *B*.

This plan, which has been termed "toll center operation," has several advantages. Applying the principles outlined in the section on the production efficiency of trunk and toll circuits, by combining into one group all toll circuits between *A* and *B*, each circuit can handle more calls than was the case where they were split into smaller groups as in Plan 1. The offices tributary to *B* receive practically local service with *B* and among themselves. They receive the benefits of the large team of toll operators at *B*, and the net result is a great improvement in the quality of service and greater economy in operating and in the use of equipment and circuits, as indicated in comparison No. 3 of "Relative Requirements." It will be noted that the circuits between *A* and *B* have been reduced from 14 to 8, while the total circuit mileage involved under Plans 1, 2 and 3 are 551, 620 and 436 miles, respectively.

This hypothetical case illustrates the application of the engineering principles which have been outlined in the discussion of the various factors entering into efficient production. As indicating how substantial may be the results of the application of these principles to a large territory, it will be of interest to state that in the territory of the New England Telephone and Telegraph Company there are over 730 central offices, nearly every one of which formerly had its own separate toll position or toll board, although in the smallest offices the toll operation was handled in combination with the local. The application of the above principles has been carried to the extent that to-day the toll traffic between these 730 offices is handled at 79 toll centers. The general effect on service has been, to place all short-haul traffic on an approximately forty second or better basis; to concentrate the longer haul high grade circuits in large groups between centers; to concentrate the long-haul toll operation at these centers, with the increased economy and efficiency of a larger and more highly developed toll force; to remove from the small offices the burden of labor entailed in handling toll calls, this resulting in a smoother local service; and, through making available large groups of trunks on main routes, affording a more speedy, dependable long-haul toll service to all offices. Thus by the use of the comparative values established through development of the unit system of equating traffic and the establishment of standards of production efficiency for force, equipment and circuits, it has been possible to improve the quality of service, conserve the investment and reduce operating expenses.

Undoubtedly the most striking development in the analysis of the toll problem is that which has pointed out the way for the evolution and systematic development of the "short-haul" system of handling toll calls.

Reference has been made to the fact that from the viewpoint of the telephone user the ideal toll service would be that which afforded the same speed of connection to a distant point as that given in making a local connection. Having this ideal in mind, studies were made to determine to what extent this type of service could be developed economically. It was demonstrated that laws could be derived from these analyses whereby it could be predetermined, with a given volume of traffic and given average holding time per call, up to what point a suitable number and grade of circuits could be provided and furnish this type of service economically.

It was found essential, in order to furnish this "short-haul" toll service, that the calling subscriber should pass his call for the distant point by number and not for a designated party. This brought out two important factors as requisite to furnishing the means and the incentive to the subscriber for so placing his calls first, the matter of the telephone directory, that the subscriber might ascertain the number desired in the distant place; second, whether the subscriber could fairly be asked to place his call by number and pay for the connection if the distant station were reached, whether his party were there or not.

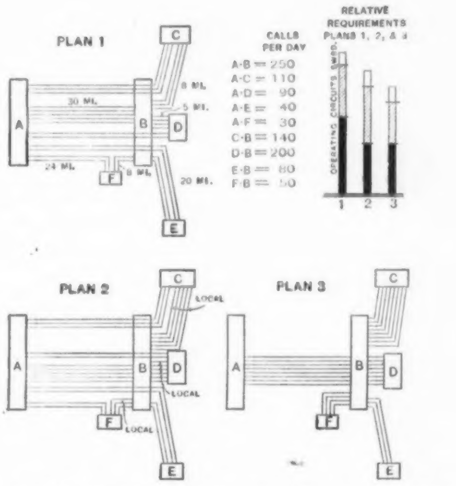

Fig. 4.—Engineering process applied to territory involving a number of offices and volumes of traffic.

Investigation of the first factor showed that as the toll calls originated from a comparatively small proporton of the subscribers, where the amount of business warranted, directories for such other places as would meet the needs could be furnished without great expense, or special lists could be made up for subscribers doing considerable business with the distant points.

In case of the second factor, analysis of several thousand toll calls to points at varying distances from the originating office showed that in 89 per cent of the calls where the station was reached, the desired person either answered the telephone or was on the premises and available to talk, and that in 6 per cent more there was some one at the station with whom the business could be transacted. It was thus demonstrated that in 95 per cent of the calls, business could be successfully transacted. It further developed that there was less demand and necessity for locating a particular person on the short-haul calls than on the long-haul calls, which is logical in that the more expensive long-haul toll calls are not usually made unless the matter is of more importance than is the case in the ordinary short-haul toll calls.

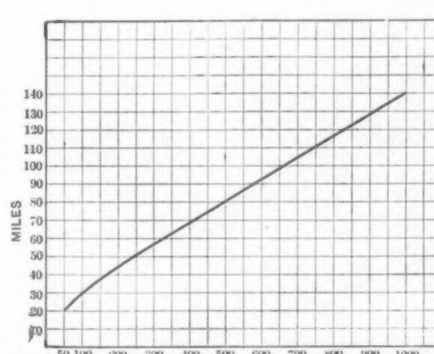

Fig. 5.—Chart determining what distance possible to furnish circuits for short-haul operation.

Based on these results, a plan was developed by which the "short-haul" traffic would be handled on an exclusively "two-number-no-delay" basis; while for greater distances, the particular person "long-haul" methods would be employed.

This plan has been gradually developed with the result that while in the year 1906 but 17 per cent of the toll traffic of the New England Company was handled on the "short-haul" basis, in 1910 over 50 per cent was handled on that basis, while the plans under development and already partially in effect for 1911, contemplate that by the end of the year at least 85 per cent of the toll traffic of the Company will be so handled. The results so far indicate that the telephone users greatly prefer this type of fast service to

the slower "particular person" service and do not find it a serious disadvantage to forego the "particular person" privilege.

It is probable that the New England territory, with its great density of towns and cities, offers ideal conditions for the development of this type of service, but it seems reasonable to expect that the telephone using public generally, will eventually express preference for toll service of this character.

As the volume of traffic increases with the growth in the business, it will be possible to offer such service on an economical basis to a far greater extent than would seem possible without a full knowledge of the facts.

It is possible to obtain a view of some of the future possibilities in the development of "short-haul" toll service by examining the chart in Fig. 5.

The curve shown in Fig. 5 is one of a set of curves made up to cover various conditions. The basic assumptions for this curve are, the use of No. 12 copper line circuit, common battery type of central office equipment, with standard operating, equipment and line production efficiency, and an eight hour telephone day, i. e., one-eighth of the day's traffic is handled during the busiest hour.

The comparisons are between the generally used single ticket particular party "long-haul" method, and the "short-haul" *A-B* ring-down method. From this chart may be determined, assuming a given number of messages per days, up to what distance it will be possible to furnish enough circuits to permit the operating on the "shorthaul" *A-B* ring down basis more economically than on the "long-haul" particular party single ticket basis. This takes into account all the factors involved that are necessary to a fair comparison. It would seem obvious that once there is an appreciation of the latent possibilities developed by this analysis, there will be steady progress toward the development of this highly desirable type of service, which can be supplied economically in case of a substantial majority of the toll calls in a territory where there are a number of closely related communities within reasonable distance of one another.

The foregoing discussion has simply covered in a broad way a few of the important problems which have been the subject of traffic engineering study for the past few years. The general problem of telephone service is so broad, and its full consideration involves so many and such a diversity of factors, that it is difficult, within the limits of a paper of this nature, to discuss comprehensively any one of its phases.

It should be apparent that the problems in connection with the production of telephone service are of sufficient importance to call for most careful analysis. The fact that the gross annual revenue of a telephone company is but a fraction of its capital investment, wherein it differs from most lines of commercial endeavor, makes such analysis a necessity. Solution of the problems of handling the traffic is fundamental to the construction engineering and equally so to intelligent consideration of matters affecting the economic and public policies of a telephone company. The determination of values in a problem affected by so many variables and the developments of simple methods of making use of them, have offered and still offer endless opportunities for a high grade of engineering.

The results of the studies so far made, have demonstrated that it is not necessary to rely solely on opinion or judgment from a certain point of view; that by analytical process many factors of apparently intangible values may be reduced to known quantities; that relations between them can be definitely and accurately established; and that from these relations certain laws can be derived which are capable of general application in the solution of telephone traffic problems.

Rapid Depreciation of Power Plant Due to Development of Business.

Mr. F. G. Gasche, in a discussion on power plants, says that the experience of many engineers would indicate that depreciation rates are generally too low, the rapid changes in an industry making a power plant obsolete so far as its primary functions are concerned. Twenty years ago the simple vertical, long crosshead type of blowing engine was installed at a group of four blast furnaces. About eight years after, half the group of engines was replaced by larger machines with large steam cylinders, so as to operate them as disconnected compound units. In fifteen years' time from the start they were superseded by improved forms of compound engines. About two years ago the new engines were assisted by gas-driven blowing engines using blast-furnace gas, with the implied intention of displacing all steam blowing engines. Now arises the specter of the turbine-driven blower. Fundamental changes in the iron and steel business imposed these changes and not the mere "obsolescence" of the elements of the power plant.—*Power.*

Engineering Notes

Agricultural Motors.—A French society known as Moto-Culture Association is engaged in promoting the use of internal-combustion and also electric motors for various agricultural purposes. After its former successful concourse it is now to hold another and larger one in the region of Paris. Various motors will be exhibited, and others will be put through trials of all kinds as applied to agricultural machines, tractors and other devices. This will bring out many new designs for farm machines, such as plows and cultivators, also others for stationary uses, such as cutter, threshers and the like, as well as for dairy work. This second exhibition and its trials promise to be the most extensive of the kind held in Europe.

Sheet Iron.—Franz Fischer, of Berlin, appears to have solved the problem of obtaining very pure iron by the electro-deposit process on a commercial scale. He now employs the process in a large works at Leipzig. The iron is said to be remarkably pure, and it is deposited on the electrodes so as to be obtained as sheets of more or less thickness. Using other electrodes, tubes can also be made. Owing to its purity the iron has unusual magnetic properties and is more easily magnetized and de-magnetized than ordinary iron. This will make it valuable for the construction of dynamos and transformers, and all electrical apparatus where the magnetized parts are made up of laminated iron. The loss in such iron, which is due to heat caused by rapid reversals of magnetism, will now be much less.

Potential and Kinetic Energy.—Potential energy is the energy which a body has in virtue of its position, as in the case of a raised weight, or of its condition, as in gunpowder. The potential energy of a pound of coal and oxygen in the right proportion for combustion is about 3,000,000 foot pounds. Of a pound of hydrogen and oxygen, the former of which burns with more heat than any other substance, is 5,500,000 foot pounds, that of a pound of gunpowder only 1,150,000, and that of nitroglycerin 2,700,000 foot pounds. Kinetic energy is the energy which a body possesses because of its motion. The kinetic energy of the shell of a 12-inch gun is about 80,000,000 foot pounds. A shell from the 16-inch gun at Sandy Hook has 175,000,000 foot pounds of energy, or about the same amount as is possessed by a train consisting of a locomotive and eleven sleepers and running at 60 miles per hour. The energy of the "Mauretania" at 30 miles an hour is 3,000,000,000 foot pounds; that of the earth in its orbit round the sun is $1,104 \times 10^{30}$ foot pounds—one thousand one hundred and four with thirty zeros after it.

Separating Hot and Cold Water Pipes.—Commissioner Thompson, of the Department of Water Supply, Gas and Electricity of New York city, has called attention to the fact that in drawing water from cold water supply pipes much waste occurs through permitting the water to run until it is cold. The heated condition of the water first drawn seems to be due to the proximity of the hot and cold water supply pipes. For this reason he had suggested that a new plumbing regulation be drawn to require the hot and cold water supply pipes to be separated by at least 12 inches. To meet this suggestion and at the same time provide for other matters affecting hot and cold water supply pipes, the following amendment to the Plumbing Regulations of the Borough of Manhattan is proposed: "Section 159—House service pipe must connect to the street mains by means of taps supplied by the Department of Water Supply, Gas and Electricity. Section 160—A stop and waste cock must be placed under the sidewalk at the curb, and also a separate stop or valve upon the service pipe just inside the front wall. Section 161—The diameters of street service pipes must not be less than 1 inch for dwellings, 1½ inch for tenement or apartment houses and 2 inches for hotels, factories and other miscellaneous buildings. Section 162—That all rising lines have a stop cock or valve at the foot of each line and a separate stop cock or valve on the branches from the riser for each fixture if isolated or each group of fixtures, such as bathrooms, kitchens, etc., located so as to be accessible at all times. Section 163—Diameters of branches to any fixture must not be less than ½ inch. For flush valves not less than 1 inch. Section 164—Where hot water supply pipes are installed, the distance between the hot and the cold risers and branches must not be less than 12 inches, and a method of circulation provided that will insure the prompt delivery of hot water at the faucet when required. Section 165—All risers and branches, where possible, must be exposed and properly fastened." These additional rules are to be published in the City Record in accordance with Section 141 of the Building Code. It is intended, says Rudolph P. Miller, Superintendent of Buildings, to make these rules uniform in the five boroughs of the city of New York, but before the same become effective any criticisms or suggestions will be gladly received.—*Engineering Record.*

Science Notes

Making Butter to Order by Electricity.—We read in the *Electrical World* that one of the customers of the New York Edison Company has a very up-to-date grocery store and has recently added to his list of electrically driven appliances a 1½-horse-power motor for driving a churn. His patrons purchase cream at the store and for a small charge have it made into butter on the spot. The method is not only an excellent advertisement for the grocer, but is also instructive for the children and others in the neighborhood. It should find imitators.

Breath Pictures.—A rather remarkable phenomenon is noted in a recent number of *Kosmos*. If the film of a negative is stripped from the glass plate, and the latter is breathed upon, after having first been thoroughly cleansed, the picture which originally formed the negative upon the sensitized film now appears as a positive in light gray coloration. A somewhat similar phenomenon is observed if a coin, for example, is placed on a highly polished metal plate for a few minutes, and is then lifted off. Upon breathing on the spot previously occupied by the coin, an exact reproduction of the design upon the latter is obtained.

Mortality from Consumption.—During the last ten years the fall in the mortality from consumption has been, in Great Britain, 19; Scotland, 24; Ireland, 24; Germany, 18; London, 30; Berlin, 24; Paris, 3. This period synchronizes with that during which the National Association for the Prevention of Consumption has been at work—also with Mr. Burns's term of office at the head of the Local Government Board; but during the same period the drink bill per head of the population in this country has fallen from $23 to $16.65. In Paris, on the other hand, no such fall has been recorded. Whether this be a cause or a symptom merely, this aspect of the question must receive careful and respectful consideration.—*Nature.*

Mosquito Sucked by Midge.—F. H. Gravely reports finding in the Sunderbunds a small Chironomid fly (*Culicoides*) with its proboscis well-embedded in the abdomen of a mosquito (*Myzomyia rossii*) and evidently imbibing nourishment from it. Probably the *Culicoides* sucks mammalian blood, and was taking it second-hand from the mosquito.—*Knowledge.*

Musical Sands.—The attention of the public has recently been directed to those curious freaks of nature, "singing sands." When a small quantity of this sand is clapped between the hands it is said to give forth a sound so shrill as actually to resemble a hoot. Put into a bag and violently shaken, the sand emits a noise strangely like the bark of a dog. The most notable of these sands are those of the Hawaiian Island of Kauai. Similar sands also occur in the Colorado desert, where also are to be found those curious moving sands that continually travel hither and thither over the vast plain of clay. Their movements are induced by the winds, and when a strong breeze is blowing the particles of which they are composed give out an audible humming or singing. Under the microscope, these sands show an almost perfectly spherical form, so that they roll on each other at the slightest impulse, a circumstance that also accounts for the rapidity with which the sands travel over the desert. One theory advanced with respect to the "singing" of these sands is that it is due to an exceedingly thin film of gas that covers the grains. Gathered and removed from the desert, the sands lose their vocal properties.—*The Engineer.*

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